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The Mining Magazine

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CONTENTS

EDITORIAL

THE Press is gradually becoming alarmed at the new regulations which permit the gas companies to deliver gas for domestic purposes containing large amounts of that deadly poison, carbonic oxide. Twice during the last year or so we have entered a protest against this quality of gas. It is encouraging, therefore, to find that *Nature* and the *Times* have taken up a similar attitude.

THE re-election of Mr. W. J. Loring for a second term as president of the American Mining Congress was a well-deserved compliment to a man of character and sound judgment. If everybody worked as hard and faithfully as Mr. Loring, and was as undaunted by difficulties, there would be no such thing in this world as hard times.

GOVERNMENT charges have gone up in most directions, not only in the postal and telephone departments. For instance, the cost of Government publications has recently been advanced in a most extraordinary manner. As a specific case, the price of the monthly returns of imports and exports is now 10s., a sudden jump from 3s., which itself compared with 9d. three years ago. Evidently some brilliant genius has hit on an idea for counteracting the effect of the abandonment of excess profits duty.

FOR the first time since the commencement of the Great War, the Rugby teams of the Royal School of Mines and the Camborne Mining School met on December 22, the match being played at the ground in the Old Deer Park, Richmond. The Royal School of Mines' team won by two goals and one try to one goal. G. R. Rougier, the Harlequin three-quarter, scored all the three tries for the winning team. He also converted on one occasion, while E. C. Airth converted the other. J. B. Simpson scored the try for Camborne, and C. V. Paull converted.

The Penalties of an Inventor

We have pleasure in publishing elsewhere in this issue Mr. Alfred James's annual cyanide letter. This year the letter partakes of the nature of a record of the difficulties with which an inventor and his backers are faced when endeavouring to introduce a new idea, and it contains an authentic account of the early struggles of the cyanide process, particularly in South Africa. An inventor is usually told first that his idea is of no value any way, and, second, that it is not new ; and too often, if it is proved to be really useful, the mine-owner will adopt it without permission, leaving the inventor to fight for his patent rights. In the case of the MacArthur–Forrest cyanide process the courts were generally unfavourable to the inventors, presumably for the reason that the selective action of weak solutions was not sufficiently indicated in the specifications, but the fact remains that in spite of legal and personal hostilities the metallurgical world is fully aware of its indebtedness to the inventors, their backers, and helpers. Unhappily, that indebtedness is still undischarged, and we are afraid that the only satisfaction Mr. James will receive for making suggestions with regard to a fund for old cyaniders will be the satisfaction of having made them.

Time goes quickly, or, perhaps we should say, memories are short, but most people appear to forget the early days of the cyanide process, no doubt conveniently to themselves in some cases. Folks even may deny that inventors are ever treated shabbily. But the feeling of antagonism to a new invention is always with us. At the present time, for instance, there is a considerable bitterness of feeling in some quarters against the inventors of the successful flotation process, in spite of the fact that the patents have been upheld in all countries of the world. Again, we have the fight against Langmuir and his incandescent electric lamp, in which the tungsten filament glows in an atmosphere of nitrogen or other inert gas. In this case the amount of current consumed in obtaining certain lighting power is much below that required for vacuum lamps, and the idea was not only new but useful. Yet manufacturers were found who were willing to make lamps on this system without reference to the inventor. Not only so, but the judge of first instance and the judges in the appeal court said that the patent was bad because the wording of the claims was not sufficiently definite, although the description in the body of the patent specification was perfectly clear. During the past month the case was reviewed before the House of Lords, and fortunately for the inventor their lordships took the common-sense view and said that the claim was clear enough when read with the general description of the lamp. Probably this was one of the simplest cases in all patent litigation, yet months of worry were occupied and thousands of pounds were spent in securing the rights of an obviously novel idea.

The Manufacture of Gold

Much has been published in the daily Press during the last month about an alleged German discovery of a method of manufacturing gold. An American professor, Irving Fisher, of Yale, in the course of a lecture on economics delivered before one of the London societies, announced that he had been credibly informed of a process for chemically manufacturing gold, and that the Germans confidently expected to pay their bill for reparations by this means. The weak point of Professor Fisher's statement is that he has no direct information on the subject, nor does he tell us who has. Moreover, he uses the word "synthetic" as applied to this gold. If gold could be made at all it would be by the direct opposite of "synthetic" methods. Readers of this MAGAZINE are aware of the fact that uranium can be changed to lead by radio-active influence, for we gave some particulars on this subject when writing of the discussions at the meeting of the British Association last year. There is no reason for believing that gold could not be produced in the same way, but it is doubtful whether it could be obtained in large quantities or at anything like a commercial price. The whole trend of modern scientific investigation goes to show that the transmutation of metals is possible, and if one specific case is definitely demonstrated, it is reasonable to suppose that other cases will be discovered eventually. But it does not follow that German "synthetic" gold would be a commercial success; at any rate, lead obtained from uranium is not in demand among plumbers. It may be remembered that thirty years ago an American named Stephen Emmens claimed to have discovered a method of making gold, and that the late Sir William Crookes took considerable trouble in investigating his method; but Emmens and his process eventually disappeared from public view without anything being done. A year or two ago Dr. Perez, of Spain, took out a British patent for converting mercury into gold, and he described his process in detail, as outlined in our issue of June, 1920. Perhaps it is this Perez process that has crept into Germany. Finally, we read in one of the American technical papers that it is an Englishman called Bond, who has discovered the method of making cheap gold. The comment of that paper is that it would just be like some blamed foreigner to invent a process of this sort at a time when the United States holds the bulk of the world's gold. This jocular treatment probably provides the best way of dismissing the whole subject of German "synthetic" gold.

Ashanti Goldfields Metallurgy

The ore deposits worked by the Ashanti Goldfields Corporation, while providing the star gold mine of West Africa, give the mining engineer and metallurgist plenty of anxiety. In the first place the ore is a brecciated schist which does not stand well, and there is a wide selvage of loose material between the ore and the country rock, so that close filling is necessary, and, second, arsenical pyrites and graphite make both amalgamation and cyaniding difficult. It is not our intention to review these questions in detail on the present occasion, for full particulars of the history of the metallurgical problem was given in the issue of May, 1916, and of the mining methods in September, 1917. Suffice it to say that amalgamation and raw cyaniding gave increasingly indifferent results as the depth increased, and that in 1907 dry-crushing, roasting, and cyaniding was adopted. This method has proved successful, and the recovery has been well over 90% for most of the time since. But during the last three or four years the economic conditions have become unsatisfactory. Labour became scarce and costly, and supplies of wood suitable for power purposes and for roasting became increasingly difficult to obtain. The only possible alternative in the matter of fuel was to import anthracite for use in the generation of gas, but owing to its high cost the opportunities in this direction are limited. The consequence of this position as regards labour and fuel has been that on several occasions operations have stopped partly or entirely, and in addition the cost of treatment has substantially increased. The metallurgical problems have been considered anew by Mr. W. R. Feldtmann, the company's consulting engineer, and he has conducted much experimental and research work both in this country and in Africa. The question was to devise some means of reducing the amount of fuel required and of labour employed in obtaining it, in order to obviate stoppages and to reduce the costs. When it is remembered that during the past year the costs have been 84s. 5d. per ton on ore yielding 87s. 9d. per ton at par value of gold, it becomes clear that something must be done to reduce this high figure. To give an idea of the rise in costs during these last few years, it is only necessary to say that six years ago the costs were 40s. 10d. per ton. The new system eventually devised by Mr. Feldtmann consists in concentrating the ore and roasting the concentrate. In this way a very much smaller bulk of material will have to be roasted, and the amount of wood and of labour expended in obtaining it will be correspondingly decreased, while the labour thus set free will be available for other purposes in and around the mine. It is believed that the cost will be reduced to 60s. per ton, but on the other hand the extraction will be lower by from 11s. to 16s. per ton. It may be supposed in some quarters that the reduction of percentage of recovery wipes out too much of the saving in cost to warrant the change over, but this is not, as we have said, the sole question to be considered. In other words, the prevention of stoppages owing to scarcity of fuel is as important a consideration as the reduction of costs. The main principles involved in the new metallurgical treatment now being adopted have been briefly described by Mr. Feldtmann. The ore will be coarse-crushed dry in Krupp mills, and then, after the addition of water, sent to Dorr classifiers. The slime will go to amalgamating tables, and afterwards to Wilfleys. The tailing from the Wilfleys will be cyanided, and the concentrate sent to the roasting furnaces. The sand from the classifiers will be reground in Hardinge mills, the product from which will be sized by Callow screens. The undersize from the screens will join the slime from the classifiers and the oversize will go to Wilfley tables. The concentrate from the Wilfleys will go to the roasting furnaces, and the tailing may probably be discarded, as the content is not expected to be sufficient to bear the cost. The roasted material from the furnaces is to be treated in grinding pans to make it suitable for cyaniding. One or two points of interest in connexion with this system of treatment may be mentioned. The rates of concentration will probably be about 20 to 1. The ore is to be crushed in the Krupp mills just as it comes from the mine, and it does not require drying. The mills are to be run dry because it will be cheaper and more convenient to do so. These mills were used previously for grinding the ore to 30 mesh, and by substituting a coarse screen a most efficient method of coarse crushing has been devised. In fact, the mills have taken the place of stamps, and the procedure confirms the experience gained at the Springs mine on the Rand, where ore is to go straight from crushers to tube-mills, though, of course, the Ashanti ore is much softer than that of the Rand. In concluding these remarks we would mention that this account of the new process is a mere outline of a programme, and that Mr. Feldtmann does not wish us to consider the details as fixed. It can only be by experience that any process can be finally settled, and modifications will necessarily be made according to advantages likely to be gained.

The Genesis of Iron Compounds

At the meeting of the Institution of Mining and Metallurgy held on December 15, the discussion on the Huelva pyrites deposits was continued, the first part of the evening being occupied by further comments on Mr. Henry F. Collins's paper read the previous month, and the latter part by a consideration of a paper relating to the mining of these ore-bodies, written by Mr. A. V. Reis, of the Tharsis Sulphur and Copper Company. An outline of Mr. Reis's paper is given elsewhere in this issue, and all we need say here is that the mining of massive sulphides is a different problem from the mining of "disseminated" sulphides, so that it is of little help to compare the methods in Utah and Arizona with those of Huelva and Broken Hill. Mr. Reis presents his subject clearly and outlines the history of the studies of mining in Huelva and the reasons for adopting certain policies.

The discussion on Mr. Collins's paper was enlivened by an address by Mr. Thomas Crook, and the interesting nature of his remarks was evidenced by the fact that, though the time allotted to the discussion had virtually expired, the closure was not applied to him by the President. Mr. Crook is an expert petrologist, and his work at the Imperial Institute and later at the Imperial Mineral Resources Bureau is well known. If his experience in the field is not as great as that of the mining engineers who spoke at the discussion, he at any rate knows the relative values of the theories of origin put forward by his brother petrologists and geologists, and is aware that many of them are mere suppositions without any basis of practical fact. In his speech he expressed his doubts of the theory of magmatic differentiation, and of the notion that the igneous rocks of any petrographic province are all derived from a common magma. He also referred to his inability to accept the theory, now so popular, that magmas give off immense volumes of water which has never previously been at the surface of the earth, and which carry upward loads of metallic matter in solution. This theory was propounded by Kemp and elaborated by Van Hise and others, and probably Professor J. W. Gregory has applied it more widely than anyone else. For ourselves, we have never accepted the theory, and have expressed this view on several occasions in these columns. It was therefore refreshing to hear a competent petrologist voice the same scepticism. No doubt it is a very convenient theory, but there is no evidence to confirm it, and the actions presumed are of remote probability. As an alternative it always seems more feasible that the waters of meteoric source circulating in the earth should be heated by the igneous flows, and that the metals either in the flows or in the sedimentaries should be concentrated thereby. Mr. Crook takes this view and he also endorses the opinion of some of the older geologists, who held that the Huelva deposits were formed contemporaneously with the enclosing slates. In his speech he drew attention to the fact that pyrite is found more abundantly in argillaceous than in any other kind of rocks, where it was formed under the ordinary conditions of sedimentation, and he argued that the effects of the igneous intrusions on such pyritic slates, coupled with later changes, would be to secure redistribution of the pyrite in practically its present condition. If this view is correct, the replacement theory becomes unnecessary in the case of the Huelva deposits, and probably its aid is generally invoked more often than is necessary. The fact that pyrite is usually found in slates and in coal gives rise to the view that sulphur is more often of organic than magmatic origin, as we remarked recently when dealing with Mr. J. H. Goodchild's paper on "Land Growth." Altogether Mr. Crook's remarks were stimulating in that they encouraged engineers to turn over in their minds the theories other than that of magmatic waters.

Another paper on iron compounds and their origin that will be read with great interest appears elsewhere in this issue. This gives an account of the immense bodies of hematite recently developed in the State of Bihar and Orissa, India, and it is written by Mr. Ernest Parsons, who has been closely connected with their investigation. The paper may be considered as an addendum to Dr. Coggin Brown's articles on the iron and steel industry of India, which appeared in our pages a few months ago. From a commercial point of view these iron ore deposits are of supreme importance in the world's iron industry. In the course of his geological studies Mr. Parsons found evidence that points to a necessity for revising the table of sequence of the local rocks as at present accepted, and he has also evolved a theory of the origin of the iron ores. He bases his theory on that of the magmatic waters, and connects the deposits with the basic igneous intrusions. He holds that the iron was introduced into the sedimentaries by hot solutions, rich in iron, accompanying the basic intrusions; that the solutions rose through faults to the series now bearing the iron, percolating through the sands and sandy shales and along the bedding planes; that the heat and pressure of these solutions fused the silica and baked the shales of the beds near the source of egress, and thus prevented further replacement of those near the source of supply, thus accounting for the fact that the ore and the igneous rock are rarely in close association. He proceeds to argue that as the solutions lost their heat and pressure replacement took place, the silica being replaced by iron. In many ways these deposits resemble those of Lake Superior, and the associations with basic igneous rocks are similar. Van Hise and Leith attribute the origin of the Lake Superior ores to solutions coming from the basic rocks, but hold that the solutions were delivered into the ocean and that the iron was precipitated from the ocean waters to form sedimentary beds. In the case of the Indian ores, Mr. Parsons considers that the original solutions went direct to pre-existing sedimentaries, and replaced them in varying degrees. We prefer to defer discussion on Mr. Parsons' views until further details are available, for much has still to be learned and investigated, but it is clear that we are here again up against the magmatic water theory.

REVIEW OF MINING

Introduction.—Most people were glad to see the last of the year 1921, and are hoping for better things in the near future. Trade is still far from satisfactory, and there will be many anxious moments yet. But there are bright spots of promise. Wages and the cost of living are both going down. Accumulations of metal in the United States are disappearing, and the copper mines will probably re-start towards the middle of 1922; buying of tin has already commenced in America, as is shown in the greatly increased shipments thither. In politics, the Irish question has assumed a much milder form, and genuine efforts are being made to put European credits and finance on a reasonable footing.

Transvaal.—The dividends announced by the Rand gold mining companies for the second half of 1921 are given in the accompanying table. Generally speaking they are

	1st half, 1920.	2nd half, 1920.	1st half, 1921.	2nd half, 1921.
	s. d.	s. d.	s. d.	s. d.
Brakpan	3 0	6 0	3 0	3 0
City Deep	2 6	4 0	4 0	3 6
Consolidated Langlaagte	1 0	1 6	1 0	1 6
Consolidated Main Reef	1 3	1 9	9	1 0
Crown Mines (10s.)	2 9	5 0	1 0	2 3
Ferreira Deep	2 0	2 6	1 6	9
Geduld	1 6	2 0	1 6	2 0
Geldenhuis Deep	6	2 6	—	—
Government Areas	4 0	6 0	5 0	6 0
Kleinfontein	—	1 0	—	1 0
Knight Central	—	1 6	—	—
Langlaagte Estate	1 0	1 6	1 0	1 6
Meyer & Charlton	10 0	14 0	10 0	10 0
Modderfontein (10s.)	4 6	5 9	4 3	5 0
Modderfontein B (5s.)	6 6**	2 6	2 0	2 9
Modderfontein Deep (5s.)	3 0	4 3	3 3	4 3
New Primrose	—	1 0	1 0	1 6
New Unified	1 0	2 0	1 0	1 0
Nourse Mines	9	1 0	6	9
Robinson Deep "A" (1s.)	2 0	—	—	—
Robinson Gold (£5)	1 0	2 0	1 0	1 0
Rose Deep	2 0	3 6	1 6	1 6
Simmer & Jack	—	6	—	6
Springs Mines	1 0	3 0	1 6	1 6
Sub-Nigel	1 0	1 6	9	1 0
Van Ryn	1 6*	1 6*	1 6*	1 0*
Van Ryn Deep	5 0	8 0	6 0	6 0
Village Deep	6	1 6	9	1 3
Witwatersrand Gold	1 0	3 0	2 0	3 0
Witwatersrand Deep	—3	—	1 0	—
Wolhuter	1	1 3	9	9

*Tax paid. **On old £1 shares.

at much the same rates as during the first half of the year, but are substantially lower than those for the second half of 1920. The total declaration for 1921 represented £7,164,000, of which over two-thirds came from the Far East Rand. The total dividends for 1920 were £8,314,300, as compared with £6,287,200 for 1919, and £5,330,000 for 1918.

South Africa is in the throes of another strike, which this time started among the coal-miners. The disaffection has spread to the white workers in the gold mines, and the long-expected strife has at last come to a head. As regards the coal position, this industry has been under a cloud lately, owing to the export business falling off. The cause of the fall is the resumption of shipment to the South African ports of British and Welsh coal, combined with the high railway charges from the mines to the coast.

At Geduld developments continue to disclose ore of high grade around Shaft No. 7. The latest cable announces that in the 6th level, at the intersection of the cross-cut, the reef averages 2 oz. over 28 inches.

A fire broke out on December 8 at the Ferreira Deep, in the 8th level on the South Reef. A number of whites and natives were suffocated both in this mine and in the adjoining Robinson. A day or two afterward there was a serious fall of ground at the main station, and several men engaged in fighting the fire were entombed. All work was stopped at the mine for nearly a fortnight.

Rhodesia.—The output of gold during November was 53,090 oz., as compared with 53,424 oz. in October and 46,782 oz. in November, 1920. Other outputs in Southern Rhodesia during November were:—Silver 13,870 oz., coal 47,779 tons, chrome ore 47 tons, copper 257 tons, asbestos 589 tons, arsenic 12 tons, mica 1 ton, diamonds 17 carats.

The dividends declared by Rhodesian mining companies during 1921 are given in the following table:—

	£	%
Gaika	34,187	12½
Globe and Phœnix	228,571	80*
Lonely Reef	81,302	30
Rezende	48,000	40
Rhodesia Broken Hill	35,000	10
Shamva	180,000	30
Wankie Colliery	56,733	10
Total	£663,793	

* Tax paid.

Land and development companies distributed £247,866. These figures relate only to public companies and do not include profits distributed by local syndicates.

Arrangements have been made for the provision of new capital for the Bwana M'Kubwa copper mine in Northern Rhodesia. A new company is to be formed with a capital of £400,000 in 5s. shares, and holders of each of the 925,053 10s. shares of the old company will be offered one new share credited with 2s. 6d. paid. The company will thus receive £115,631 in cash, but the underwriters have calls which will bring in a further £168,736. To bring the operations to the scale contemplated, say 20,000 to 30,000 tons of copper per year, additional capital will be required later on. A report on the property has been made by Mr. A. B. Emery, of the Messina mine. He states that down to 450 ft. there is 3,000,000 tons of ore, averaging 4%, and that the ore is likely to persist to considerable depths below. It is proposed to concentrate by the Minerals Separation process, and smelt to best selected.

West Africa.—Companies of which Mr. Percy Tarbutt is chairman operating gold and diamond ground in West Africa are to be amalgamated. These companies are the Goldfields of Eastern Akkim, the Akim Alluvials, and the Akim Diamond Field. Options have been granted to an Anglo-American syndicate on ground that is believed to be suitable for gold-dredging, and this syndicate has also been examining the diamond ground.

Nigeria.—The Premier Hydraulic Tin Mines, a company formed 18 months ago to work properties at Jemaa, is issuing £50,000 debentures for the purpose of providing further working capital. It was found impossible to bring the heavy machinery originally designed by Mr. J. J. Garrard to the properties, owing to the absence of suitable roads, and Mr. Garrard has since made modifications in the design to meet requirements. In the meantime, tin-winning has been done by calabashing, and the yield up to date has been 165 tons of tin concentrate.

Australia.—The Broken Hill Proprietary Company announces that competition from Europe is having a serious effect on its iron and steel business at Newcastle, New South Wales. Before the Christmas holidays three blast-furnaces were at work, but with the new year only one will be in blast, and the scale of operations at the steel plant will be correspondingly reduced. The directors point out that labour conditions in Australia continue to become more difficult, as regards both high pay and short hours, whereas in Europe there has been a tendency lately to more economic conditions. It is stated that not even the present high tariff will keep European steel out of Australia.

The final yearly report issued by the Kalgurli Gold Mines, Ltd., records that a profit was made of £21,574 from the treatment of 49,320 tons of ore, of which 15,493 tons came from other mines. A dividend is now being distributed absorbing £24,000, being at the rate of 20%. The company has sold its mine and plant to the Oroya Links for £20,000, as already reported, and it has a reserve fund invested in first-class securities valued at £86,237.

The Mount Elliott company is still waiting for a suitable opportunity for raising additional capital in order to erect leaching plant as a substitute for the smelter in the treatment of the great reserves of low-grade and unconcentratable ore. We described Mr. W. H. Corbould's proposed roasting and leaching process in the last issue. At the meeting of shareholders held on December 20, it was announced that the board had virtually received promises for the required £350,000.

In the November issue we recorded that work at the Mount Bischoff tin mines in Tasmania had been suspended on account of quite unaccustomed snowstorms. Operations were started again in a week or two, and continued for a short time. It was found, however, that no profits were being made owing to the low price of tin, so the mines have been closed down again.

India.—The Cape Copper Company reports a deplorable condition of affairs at its Rakha Hills mine, in Chota Nagpur. During the past year it has been possible to smelt only 19,941 tons of 4% ore, though the mine has 300,000 tons of developed ore and a complete metallurgical plant. Difficulties of transport, fuel supply, and labour, combined with breakdowns of the plant, have brought about this result. The directors attribute this position of affairs largely to the disturbed political conditions in India, but there may be other causes, seeing that the political effects are not so noticeable with other mining ventures in the same district.

Malaya.—Rumours have been prevalent lately to the effect that the Federated Malay States Government is about to realize its stocks of tin bought a year ago with a view of supporting the market. The Government now announces that it has no intention of selling these stocks until a profit can be shown. Judging by price records, these stocks were bought at prices averaging perhaps £225 per ton. Thus tin producers are relieved of the fear that a substantial rise in price would be prevented by these stocks coming on the market at present.

It is reported that a Singapore syndicate is developing lode-gold mines in the north of Kelantan, close to the Siamese border.

A stamp-mill with a capacity of 30 tons per day is in course of erection.

Cornwall.—An inquiry was recently held on behalf of the Government by Mr. W. Forster Brown into the drainage question in Camborne district, more particularly with the object of devising a means for joint action in this matter by East Pool and South Crofty. His recommendation was handed in late in December, and it was found to involve a joint pumping scheme at New Cook's Kitchen shaft. South Crofty has accepted the proposal, but East Pool does not see that any advantage is likely to accrue. In the meantime we understand that South Crofty has purchased the pumping engine from Fortescue's shaft at Grenville.

The Kingsdown (Hewas Water) Tin Mines, Ltd., is increasing its capital from £60,000 to £80,000 in order to provide additional funds for development and plant. The main shaft is to be sunk a further 150 ft. below the 210 ft. level, and estimates are being prepared for a dressing plant having a capacity of 2,000 to 3,000 tons per month. The results of development continue to be good. The company has recently acquired an interest in the King's Wood property in Devonshire, which contains pitchblende.

English Oil.—There has been much agitation recently among shareholders in English Oilfields, the company which is developing the oil-shales of Norfolk, owing to the continuous delay in obtaining practical results. Consequently the board has been rearranged. No doubt the new directors will investigate matters, but what is still wanted is a director who has an intimate knowledge of oil technology.

Mexico.—The Mexican Corporation has issued a report of progress at the Fresnillo silver mine, and at the Teziutlan copper mine. At the Fresnillo mine the old cyanide plant was operated until December, 1920, when the low price of silver made it advisable to suspend operations, and the old leaching plant working on tailings was stopped in March, 1921. The new plant was started on August 1, 1921, treating about 45,000 tons per month, the amount to be gradually raised to 75,000 tons per month. The ore now treated comes from the old open-cut, where the ore averages slightly over 5 oz. of silver. Development of the old underground workings is to be undertaken. At the Teziutlan mine a new ore-body has been proved, averaging 5·5% copper, 28·5% zinc, 1·75 dwt. gold per ton, and 5·4 oz. of silver per ton. The fall in the price of copper made it necessary to cease smelting in November, 1920. From the time the company acquired the property until this date, 52,088 tons of ore was raised, and 11,593 tons of concentrate and 16,632 tons of ore was smelted, yielding 1,009 short tons of copper, 54,104 oz. silver, and 700 oz. gold. It is not possible to separate the copper and zinc sulphides by selective flotation, owing to their intimate association. According to present practice all the zinc is lost in smelting.

Colombia.—The purchase and erection of the new treatment plant at the Constancia lode-gold mine, which is being developed by the Colombian Corporation, an offshoot of Oroville Dredging, has been delayed owing to the desirability of building a road from Dos Bocas on the Nechi River to the mines, a distance of about 50 miles. It is probable that the road will be completed and the plant installed by the end of 1922. In the meantime the mine has been developed and the metallurgical methods have been investigated. Mr. Prichard reports the ore reserve above the 3rd level at 300,000 tons, averaging $6 to $8 per ton, and the reserve between the 3rd and 4th levels at 70,000 tons, averaging $8 to $10 per ton. The working cost he estimates at $3 per ton. The new mill will have a daily capacity of 300 tons.

Venezuela.—The South American Copper Syndicate, which has reopened the old Aroa mines, is issuing £25,000 additional capital, chiefly with the object of erecting a new smelter, as recommended by their recently appointed metallurgist, Mr. William Spalding. Mr. C. H. Stewart, of the firm of Alexander Hill & Stewart, is about to visit the property.

Argentine. — The Anglo-Persian Oil Company announces that oil has been struck at Commodoro Rivadavia, one of the test wells yielding a flow of 400 barrels per day from a depth of 2,000 ft. Five other wells are being drilled in this district, and the Nequen and one or two other districts are to be tested almost immediately.

Russia.—The rehabilitation of Russia is once more being considered, and though nothing definite is known there seems to be a disposition on the part of the Soviet Government to take a step towards sane economics. A sign of this change is provided by the fact that the Soviet has expressed a desire to reopen negotiations with Russo-Asiatic Consolidated.

INDIAN IRON ORES

By ERNEST PARSONS, M.Sc., F.G.S.

The author gives particulars of recent developments of high-grade iron ores in Bihar and Orissa, India, and presents a theory of their origin.

Introduction.—It has long been known that iron ores occur in many parts of India, but only in the last few years have investigations brought to light the extensive deposits of high-grade hematite ores of Chota Nagpur, Orissa, and parts of the Central Provinces. During the past five years prospecting work has been vigorously prosecuted, and has resulted in the discovery of iron ore deposits, which both as regards quality and quantity undoubtedly excel those of the Lake Superior area, hitherto the richest known field in the world. In a recent issue of the Magazine, Dr. Coggin Brown, of the Geological Survey of India, has contributed an article on the "Iron and Steel Industry of India," in which a brief reference to these ores was made. The remarks in the present article apply to the extensive field lying to the east of the Bengal-Nagpur main line in the Kolhan estate of Singhbhum District and the Feudatory States of Bonai, Meonjhar, and Mayurbhanj.

Topography.—The total area of the iron-ore bearing country is certainly not less than 1,000 square miles, and comprises the hilly forest tracts of the above-mentioned district. The country has an average height above sea-level of about 2,000 ft., but several of the ranges rise to well over 3,000 ft. above sea-level. The plain country has an elevation of between 1,100 and 1,500 ft. The iron-ore bearing region is invariably covered with valuable forests of sal trees, which furnish a hard wood extensively used as railway sleepers. The only cultivated tracts within this area consist of alluvium and shale outcrops. The topography of the area is undoubtedly due to the weathering of the iron ore series. The relatively hard hematite quartzite and ores have resisted weathering and given rise to the highlands; while the shales have formed the valleys and steep slopes. The ore-field is drained by the Kharkai River (a tributary of the Subainarekha River), the Karo and Koina Rivers (left bank tributaries of Koel River), and the Baitarani River. The principal deposits are situated along the headwaters of the Karo, Koina, and the Baitarani Rivers.

Geology. — On maps of the Indian Geological Survey, the iron-ore bearing rocks are shown as Dharwars, and the associated igneous rocks are mapped as part of the fundamental complex. Dr. Coggin Brown in his map published on page 15 of the July issue of the Magazine, also shows the iron-ore bearing series of Dharwar age, but speaks of the granites as intrusives into the Dharwars. The writer has discovered evidence which proves undeniably that the iron-ore bearing series are of much later age than the Dharwars, and that the associated igneous rocks are the newest of the area.

The following classification of the rocks in their true sequence, No. 1 being the oldest, has been established :—

(1) Dharwar rocks.

(2) Iron-ore series.

(3) Intruded acid (granite) series.

(4) Intruded (and possibly extruded) basic series.

The history of the area is relatively simple. The oldest rocks are the Dharwars, which are a highly metamorphosed complex of hornblende, steatite, quartz, and mica, and quartz schists with schistose basic and ultra-basic intrusions. After considerable upheaval and alteration these rocks were extensively denuded, and after a very considerable lapse of time the iron-ore bearing rocks were deposited on their weathered surface. The marked unconformity between these two series is seen wherever the junction has been observed.

The iron ore series are predominately shaly, but a few lenticular sandstone beds occur. This series is certainly not less than 2,500 ft. thick, but its thickness is difficult to estimate owing to the presence of a number of strike faults.

This period of sedimentation was followed by one of exceptional igneous activity. First a granitic mass was intruded into the Dharwars disrupting them and absorbing considerable quantities of these rocks. The iron ore series were evidently relatively unconsolidated at the time of the intrusion, and offered less resistance to the intrusion than the Dharwars. They were uplifted rather than penetrated by the granites. That some absorption did take place is evidenced by the fact that the granites are found in contact with the limestone and lower shales, as well as with the basal conglomerates.

The period of acid intrusion was followed, probably after no great lapse of time, by the basic intrusion. In the granites, these are usually found in the form of dykes with a general N.N.E.—S.S.W. trend, and rarely penetrate the iron ore series. These dykes can be traced at least 80 miles from the vicinity of Holdepukkur southwards to Keonjhargarh. The basic intrusions into the iron ore series are usually in the form of batholiths, as at Lipunga in the Kolhan, south of Cheliatoka Peak in Bonai, and on the Singhbhum-Bonai boundary near Korai. Dyke-like intrusions are occasionally found, but are invariably associated with faulting.

About the same time as the last intrusion, the area was subjected to considerable earth-movements, which will be considered later.

Dharwar Series.—Undoubted Dharwar rocks are well exposed in the neighbourhood of Holdepukkur, but are cut off to the south by the granite intrusion, which outcrops near Chaibassa. A large inlier of these rocks occurs north of Jaganathpur and has given rise to the range of hills with an east and west trend, which form the watershed of the Roro and Deo Rivers. These rocks are cut off both to the north and south by the granite and are overlain by the iron ore series. The principal rock of the area is a quartz and mica schist, but altered ultrabasic rocks with asbestos occur; and there is also a considerable development of steatite schists, which are used by the natives in the manufacture of food vessels. The series is penetrated by numerous quartz veins, which form small knolls.

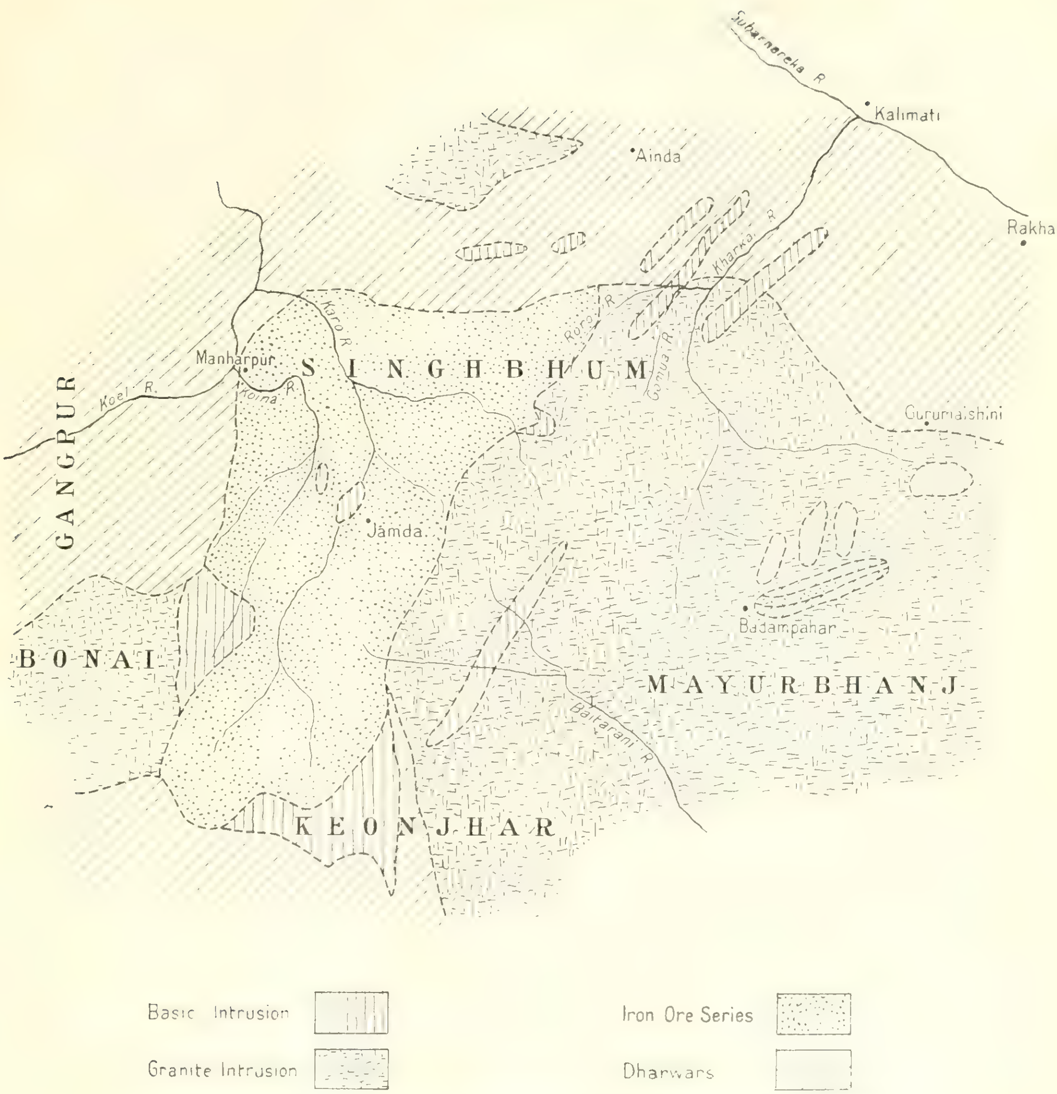
The rocks have a general east and west strike, and the dip is to the north usually at a high angle. Local variations of dip and strike are common. The copper and apatite deposits of Singhbhum occur in these rocks.

Intruded Acid Series. — The consideration of the iron ore series is purposely deferred till later. The acid or granite intrusion is of enormous extent, and forms the extensive plains of Singhbhum, Mayurbhanj, and Keonjhar. A smaller outcrop of these rocks is found about ten miles north-west of Bonaigarh. The intrusion is of highly acid character, and at the margins pegmatitic and aplitic off-shoots are frequently found. The principal minerals seen in the hand specimen are quartz, felspar, and a little dark mica, in order of importance. There is very little, if any, gneissose structure. The most interesting occurrence of these rocks is seen in the Gomua River valley, south-west of Chaibassa. The Gomua river is a small right-bank tributary of the Roro River. Here the granites are intruded into the Dharwars and the iron ore series. In the hills forming the watershed to the south of Siringsia, the intrusion into the schists is well exposed. A careful examination of the country to the south of Bara Lisia will disclose wisps of schists caught up in the granite.

A description of the intrusion of the granites into the iron ore series near the village of Rajanka in the Gomua valley is probably advisable, in view of the fact that the former have been mapped as of Archæan age. The iron ore series are represented by a shaly quartzitic conglomerate, which in parts is manganiferous, and has been worked for that mineral in the neighbourhood. These are the basal beds, and they are overlain by a thin shale band, into which quartz intrusion took place, and which is now represented by cellular quartz, the shale having been washed out. Above the shale band are about six beds of marmorized limestone, totalling about 40 ft. in thickness and in turn overlain by calcareous shales passing upwards into ferruginous shales.

The iron ore series in this valley have a very slight dip to the west, the strike being approximately north and south. In the vicinity of Rajanka there is considerable variation of dip and strike. The basal conglomerate here gives rise to a small scarp rising about 50 ft. above the valley, and usually forming the eastern bank of the stream which is excavated in the limestone bed. A number of excavations in the alluvium were made to prove the limestone, and a remarkable series of potholes, subsequently filled by gravels and alluvium, were disclosed; almost half the limestone had been eroded. At Rajanka the stream takes a bend to the east, round a small knoll caused by a granite intrusion into the limestone. The basal conglomerate and the shale band have disappeared, and the limestone and granite are in contact. A careful examination of the limestone clearly proves the intrusive character of the granite, small aplitic veins penetrating the limestone in all directions. These veins can be followed through the different beds of limestone. The iron ore series have here been uplifted as well as penetrated by the granite intrusion.

The granite, being a relatively soft rock,



The Iron Ore District of Singhbhum, Keonjhar, and Mayurbhanj.

has given rise to the rolling plains of Mayurbhanj, Keonjhar, and Singhbhum. A hard variety of this stone, which is very acid, has been used as a building stone in the erection of the spill bridge over the Baitarani River. A considerable business has recently sprung up around Chaibassa in the mining of kaolin, derived from the decomposition of this acid rock.

Intruded Basic Series. — These are met with everywhere throughout the area. In the granite they occur principally as dykes and as such can be traced for miles in the Mayurbhanj, Singhbhum, and Keonjhar districts, where they give rise to the highlands. A large batholithic intrusion of these rocks occurs in Bonai and Keonjhar, north of the Brahmini River, and the Pal Lahara boundary. Another occurs in the north of Bonai, along the Singhbhum boundary, and a smaller one in the Kolhan estate near Lipunga. North of the iron-ore bearing country in Singhbhum large tracts are composed of this rock, and of shales metamorphosed by their intrusion. The striking feature here is the enormous amount of absorption that has taken place. This fact is well seen in the small batholith near Lipunga in the Landir Nulla.

The principal rock appears in the hand

specimen to be a dolerite. Mr. H. Cecil Jones, of the Geological Survey, has examined a few of these rocks, and states that one of the rocks is a volcanic ash. In two or three localities in Keonjhar there are rocks with porphyritic crystals of felspar in a fine-grained groundmass. The most interesting occurrence of these rocks was noted in the Karo River, about four miles down-stream from Lipunga. Here the river takes a sharp bend to the west and cuts through the main range. Here are found magnificent exposures of fault breccias. The breccias are composed of fragments of the porcellanized iron series and hematite quartzites with basic igneous rocks. Sometimes the basic rock forms the groundmass of the breccia, and in others occurs as brecciated fragments in a hematite groundmass.

The basic rocks are the latest rocks of the area, and there is little doubt that their intrusion followed very closely upon that of the acid series. This is suggested by the fact that like the acid series they rarely penetrate the newer sedimentary rocks except in the neighbourhood of faults. The intrusion of this series was obviously extended over a considerable time, as evidenced by the sections of the Karo River above described.

IRON ORE SERIES.—This is a succession of shales and sandy shales with a few lenticular bands of quartzite. The following is probably the succession :—

(1) Basal Conglomerate.

(2) Limestones.

(3) Lower shales, white and purple, with some ferruginous shales.

(4) Hematite quartzites.

(5) Ores.

(6) Ferruginous shales with some ore.

The Basal Conglomerate.—This bed is found along the eastern boundary of the formation. It first appears at Chaibassa, and can be traced south into Keonjhar. At Chaibassa it is a manganiferous shaly grit, and has been worked for that mineral three miles southwards. Further south it becomes more conglomeratic, but is still shaly. It is of no great thickness, probably 75 to 100 ft. being its maximum. It is overlain in the Gomua Valley by a thin shale, which outcrops usually as a bed of cellular quartz, the whole bed having been penetrated by thin quartz stringers, which, on weathering, remain while the shale is washed out. A manganiferous bed near Mahudi is believed to represent this horizon, but this point has not yet been definitely settled. Should this prove to be the case, the succession and thickness of the whole formation will be easily determined. At present, owing to the great similarity of the beds throughout the series, it is difficult to establish a true sequence.

The Limestones.—The whole of the calcareous group will be about 100 ft. thick, but only the lower 40 ft. contain rocks sufficiently free from insoluble matter to be termed limestones. These are highly marmorized limestones of a white and pink colour, with a fairly low percentage of magnesia, but an insoluble content varying from 7 to 14%. Throughout the beds are planes, along which there has been a considerable development of chlorite and talc. As pointed out earlier they are locally penetrated by fine stringers of aplite.

Lower Shales.—These are overlying the calcareous group, and are highly ferruginous in most localities. They weather like paper shales, due to the development of an incipient cleavage. In the district south-west of Chaibassa they contain numerous stringers of vein quartz. It is extremely difficult to correlate these with the shales outcropping in the areas where these series are iron-ore bearing. It is thought that they are there represented by the white and purple shales well seen in North Keonjhar. The presence of faulting renders it impossible to trace the succession with any degree of certainty. In the upper parts of this group thinly bedded shaly sandstones are found. These are well seen along the Jamda Gamharria Road, near Kotgad.

Hematite Quartzites.—Overlying the purple and ferruginous shales in Keonjhar and the Kolhan estate are a series of quartzites, which vary from pure white quartzite to hematite quartzites almost rich enough in iron to be regarded as ores. These vary considerably in lithological characters. Some are silicified shales interbedded with hematite; others, cherts with varying quantities of iron, and jaspers. A common type is a banded rock consisting of jasper and hematite. These beds when traced laterally frequently pass into ore. This is well seen on the Katamati Range, where the Maha Dev Nasa Nulla cuts through the range. An interesting example of this rock is seen in the nulla, to the south of Bai Buru, on the Sasangda Plateau, where the rock consists of white porcellanized shale with interbedded hematite bands. Many of these rocks are very like the taconites and jaspillites described by Van Hise in his monograph on the Lake Superior iron ore field.

Upper Ferruginous Shales.—The upper shales are very ferruginous and frequently contain bands of ore. The shales have a felted appearance, well seen on the incipient cleavage planes. They frequently give rise to large deposits of laterite, due to their breaking down and subsequent lateritization. Where they contain thin ore bands they give rise to a curious cemented conglomeratic ore, which has been termed, apparently wrongly, "lateritoid." These will be described later.

The main group of the series are the shales, the hematite quartzite and ore being locally absent. These shales are frequently sandy, and the sandy beds are often lenticular. The strike of the series varies considerably. In the outlier north of Jaganathpur they are striking east and west, with a very slight dip to the south. Along the eastern boundary of the outcrop they have a north-north-east strike, and a gentle dip to the west. In the country west of the great fault, to be described later, they have a north and south strike, which gradually swings round to the north-east as traced northwards, and a steep dip to the west. They are acutely folded west of this fault, and in the Indian Iron & Steel Co.'s mine at Gua there is indication of an overthrust.

In the extreme south of Kolhan and North Keonjhar, in addition to the earth movement from east and west above described, the rocks have also been subjected to earth movements from the south and north, which have resulted in a rolling structure in this part of the field. The same is seen in the Koida division of Bonai. This is responsible for the more extensive outcrops of ore in Bonai and Keonjhar.

The junction of the ore-bearing series with the Dharwars and the granites in the east has already been described. On the south they are cut off by a large basic intrusion south of Cheliatoka Peak. In the west in Bonai they are cut off by a granite intrusion, but the sequence in the extreme south-west of Singhbhum has not been traced.

The map accompanying Dr. Coggin Brown's paper in the July issue of the MAGAZINE shows the rocks to the south-west as Cuddapahs. It is possible that the iron-ore bearing rocks are of Cuddapah age, and the sequence to the south-west is a normal one. As far as the writer is aware, there is no evidence available on this point, as nowhere are the iron ore series in contact with any sedimentary rocks of established age. It is possible that the basic intrusions occurred at the time of the intrusion of the Deccan traps, in which case the iron ore series must be pre-Cretaceous in age.

EARTH MOVEMENTS.—The intrusion of the basic rocks synchronized with earth movements of considerable intensity. Evidence of this can be seen from a study of the Geological Survey's map of Chatua and Jarida areas. Here evidence of extensive faulting was first seen, and a fault of considerable magnitude is found running along the foot of the range along the eastern edge. Evidences of this fault have also been found further south, well into Keonjhar, and it is exceedingly possible that it extends into Bonai at the foot of the Bichakhani Range. It is impossible to measure the amount of the throw, as the rocks are members of the iron ore series on both the up and down throw sides, and their relative age cannot be determined. The down throw is undoubtedly to the west. A series of parallel faults have been noted in the vicinity of Jamda and Bokan, and have been traced for some considerable distance. The faults are indicated in the field by the presence of fault breccia. The principal rock of the breccia is a chert with varying percentages of hematite.

The result of the faults has been to cause the rapid disappearance of the iron ore series to the west, where they have been considerably disturbed and given steep dips to the west. A further effect of the faults was to relieve the rocks to the east of the lateral pressure affecting the area. Consequently while to the east of the fault the iron ore series have a rolling structure, to the west the beds are very highly crumpled and have very steep dips to the west. Generally speaking as a result of this, to the west of the fault the width of the ore outcrops is really a measure of the thickness of the bed, while to the east the outcrops are more or less coincident with the rolling bedding planes.

The trend of the main fault can be easily determined from the topographical map. The scarp, traceable from Bichakhani Hill in the south of Bonai to the point where the Karo River pierces the range and takes a bend to the west, marks its direction. The course of the Karo River is probably determined by this fault. The topography of the area, as before pointed out, is due entirely to the weathering of the members of the series. The hard ores and hematite quartzites have given rise to this extensive range of hills, the trend of which is roughly coincident with the strike of the rocks.

After the formation of the ores, the whole area was uplifted, and subject to such heavy denudation that the water courses became choked with detrital material. These accumulations are well seen in the small nullas around the Thakurani Peak, where there are enormous developments of cemented river gravels, consisting either of ore, hematite, quartzite, or a mixture of the two rocks. At the present time the area is being slightly uplifted, as is clearly shown by the fact that the streams are excavating in the detrital material above mentioned.

The Mayurbhanj State deposits of Gurumahisani, Badampahar, etc., have been considerably faulted and folded, but they owe their position undoubtedly more to being caught up and uplifted by the granitic intrusion than by dynamic forces. They are undoubtedly easterly outliers of the iron ore series. A southerly outlier, in the Dharwar country west of Keonjhargarh, is found in the highest peaks of the district at the two Ganda Mardan Hills. The relation of the ore series to the Dharwars in this area has not been studied.

THE IRON ORES.—The whole of the iron ores of this area are hematite. In the large dolerite intrusion comprising the country to the south of Gurumahisani in Mayurbhanj State, a titaniferous magnetite has been noted. These titaniferous ores are quite distinct from the iron ores of the iron ore series, and are undoubtedly magmatic segregations in the dolerites. The iron ores of the sedimentary series may be classified on lithological grounds as follows :—

(1) Massive steel-grey granular hematite.
(2) Laminated hematite.
(3) Lateritic hematite.
(4) Conglomeratic or " detrital " ore.

Massive Ores. — These are fine-grained granular ores, with a steel-grey colour on a freshly fractured surface. On a weathered surface they are usually of dark red colour with a dull polish. This ore is never crystalline like the hematite ore found at Chanda in the Central Provinces. No crystalline hematite is known in these rocks. This class furnishes the highest grade ore, and samples have returned as high as 69·9% of metallic iron ; as the oxide is in the ferric condition it will be seen that it is practically pure hematite. This type is usually found in lenses in the hematite quartzites, or as the core of the larger ore masses. They are frequently found passing gradually into the laminated type. The average metallic iron percentage in this type is between 67 and 68 per cent.

Laminated Ores.—The highest grade laminated ores are very like the former, with the exception that the steel-grey ore is in laminæ varying up to an inch in thickness. The partings vary considerably in thickness, and consist of either very thin shaly partings or highly ferruginous lateritic material. These ores, especially these with thin laminæ, are very prone to lateritization, and pass gradually into the lateritic ores. They vary in iron content from about 60 to 65 or even 67% of metallic iron. These are found near the margins of the larger ore masses, or interbedded with the upper ferruginous shales.

Lateritic Ores.—Enormous deposits of lateritic material are found throughout the iron ore series. This lateritic rock varies considerably in its iron content. Only those which contain 60% or over of metallic iron have been regarded as ores. Practically the entire outcrop of the ferruginous shale has been converted into laterite. This laterite is the product of surface weathering, and is undoubtedly due to surface waters rich in iron percolating through the soil and subsoil and replacing the silica by ferric oxide more or less hydrated. This laterite never occurs in large masses sufficiently free from insoluble matter to allow of their being regarded as ore.

The lateritic ores are invariably derived from the lateritization of the upper shales where they have contained thin bands of ore interbedded with the shaly material. They are usually of relatively small size, and sporadically developed in the upper shales. They invariably give rise to small knolls in the shale country. They are also found at the margins of the larger ore masses. These laterites vary from very low percentages of iron up to 63 to 65%.

Conglomeratic or Detrital Ore.—In previous notes by the writer on these ores they have been called " lateritoid " ores, but Dr. Fermor, the originator of the term, objects to its use in this connexion, as the deposits are not derived in the same way as his original lateritoids. This type of ore is found either in the valleys in the neighbourhood of large ore masses, or as cappings to the hills composed of the upper shales with thin ore bands, or on the plateaus overlying the more ore less horizontally bedded large masses of the eastern portion of the ore field. It is undoubtedly formed in one or other of three ways, either :—

(1) By the cementation of "drift" or "float" ore from ore masses by rich laterite.

(2) By the breaking up of the laminated ores and their recementation in place of laterite.

(3) By the cementation of "fan" or river gravels carried from the ore masses.

Some of these "detrital" ore masses attain very considerable proportions. Examples of the first type are seen on the Pachri Buru ore mass in South Kolhan, and around Thakurani Peak, in Keonjhar. The second type are very well exposed on the Boradho Range in Keonjhar, and a small exposure near Jamda, where pitting work has clearly proved the origin of the bed. The last type is excellently exposed in the upper reaches of the Naomundi and the Chota Baljori Nullas, in Kolhan, and in the Kendra Nulla in Keonjhar.

Some of the last type are valueless owing to the admixture of hematite quartzite rocks in the conglomerate, but many will furnish large supplies of excellent ore, without any picking. The exposure in the Kendra Nulla is at least 50 ft. thick in one place, and covers at least two square miles. Occasional patches contain excessive quantities of lean laterite or hematite quartzites, but on the whole the majority is workable.

Composition of the Ores.—As pointed out above, many of the ores are practically pure hematite. Many analyses have been made, and apart from their remarkably high percentage of metallic iron, they are especially notable for their low sulphur content. Usually there is not more than a trace of this element and in no case has it risen above 0·06%. None of the ores has shown any appreciable percentage of titanium, nothing more than a trace being usually reported. The percentage of insoluble matter varies considerably. The massive ores show the least and the lateritic ores the greatest. The insoluble matter in the massive ores is largely silica, but a considerable quantity of alumina is frequently found in the lateritic types. The percentages of insoluble matter vary from 0·05 to about 11%.

The phosphorus percentage is extremely variable. Generally speaking, the lateritic types of ore yield the highest percentage of this element, and in this type the average will be about 0·100%. Some of the massive ores are extremely good bessemer ores, but it cannot be said that all the massive ores are sufficiently low in this element to be classified as bessemer ores. The highest percentage of phosphorus recorded in any sample was from the Ganda Mardan outlier, which ran as high as 1·500%, but this is exceptionally high. The average is about 0·080%.

The percentage of manganese in the ores is extremely variable, particularly in the lateritic varieties. The massive type and laminated steel-grey type rarely contain over 1% of this element. In several cases the lateritic ores pass gradually from leaner iron ores into manganese ores, and numerous cases of 50% iron ore passing gradually into 50% manganese ores could be cited. These occurrences are invariably in the lateritic deposits in the upper shales. The 50% manganese ores are in every proved case merely surface enrichments, and when followed to depth the percentage of manganese decreases as the iron increases.

Analyses of Iron Ores

Locality.	*Iron.*	*Manganese.*	*Phosphorus.*	*Sulphur.*	*Insoluble Residue.*
	%	%	%	%	%
Jamda	66·58	0·61	0·028	*nil*	2·23
Jamda	56·90	1·62	0·035	..	10·04
Mayurbhanj . . .	68·35	trace	0·007	0·003	1·42
Sasangda	64·37	..	0·058	0·015	1·12
Katamati } Block I	63·33	..	0·088	0·030	2·11
Pachri } Block I	63·94	..	0·072	0·024	1·49
Diraisum	62·50	,,	0·108	0·026	1·78
,, (average) .	62·95	,,	0·087	0·018	1·47
Gurumahisani. . .	60·38	0·72	0·110	—	4·97
Tatiba No. 1 . . .	62·60	0·32	0·012	0·014	2·14
Tatiba No. 2 . .	65·30	0·23	0·009	0·010	1·56
Silpoi	62·60	0·17	0·016	0·014	7·02

All the types of the ore have been used in blast-furnace operations in India. As they contain little or no magnetite and are non-crystalline, they are easily worked and the coke consumption is relatively low. The lateritic and finely laminated ores yield rather high percentages of fines on mining, and the iron percentage decreases with the size of the fines.

Origin of the Ores.—For some years the writer had great difficulty in formulating any working hypothesis which would explain the characters of the deposits satisfactorily. An examination of the Chatua and Jarida areas provided the best indications of the probable origin of the ore. In the study of this subject the ores themselves furnish very little evidence. The associated rocks, especially the hematite quartzites and breccias, in which alteration has not progressed so far, are much more valuable in this respect. In was found that associated shales had frequently been porcellanized; *lit par lit* structure, or what was comparable to this structure, was found in the thinly bedded sandy shales, which had become hematite quartzites; brecciation of the thin interbedded shaly bands in the hematite was noted, and structures that were comparable with flow structure were noted. Jaspery quartzite and iron-stained silica and chert are invariably found in close association with the ore. It is difficult to imagine any other origin for these ores than that by replacement. The degree and extent of alteration of some beds and the freedom from alteration, or even staining, of other associated beds, makes it extremely difficult to imagine that such alteration is the result of enrichment by percolating surface waters. There is no doubt that replacement has taken place by surface waters in associated beds, but the main ore masses are not attributable to such alteration.

The writer had noticed that basic igneous intrusions were always associated with the ore masses, but no definite connexion between the two was established until the Chatua and Jarida areas were examined. As pointed out before, the igneous rock is found both as brecciated fragments and as matrix in the fault breccias. The matrix in other portions of the breccia is hematite; and porcellanized shale, quartz jaspers, and hematite quartzites are the brecciated fragments of the breccias. This suggested to the writer the following origin, which would explain the characteristics noted in ore-bodies and associated rocks mentioned previously.

The iron was introduced into the sedimentary series by hot solutions rich in iron, accompanying the basic intrusions, which are prevalent throughout the area. These solutions rose through faults to the iron-bearing series, through which they percolated through the sands and sandy shale beds, and along the bedding planes. The heat, and possibly the great pressure, of these solutions fused the silica and baked the shales of the beds near the source of egress, and thus prevented further replacement of these near the source of supply. This would account for the fact that the ore and the igneous rock are rarely in close association. As the solutions lost their great heat or pressure, replacement rather than fusion took place in the rocks, through which they percolated, the silica being replaced by iron. On the margins of the ore field numerous cases of quartz ironstone dykes are noted, which may represent the impoverished solutions. The enormous quantity, strength, and possibly pressure of the solution caused even the shales to be attacked by the iron oxide.

The deposit of hematite at Sulaipat in the Mayurbhanj State outlier is most instructive. Here there is a great development of "drift" or "float" ore, which has been proved by pitting to rest on altered granite. The solid ore masses on the hill are very closely associated with basic igneous (dolerite) dykes, the whole hill being reticulated by these dykes. The only associated sedimentary rocks are sandy shales, quartzites, and hematite quartzites. The solid ores, here, are of small dimensions, and have a remarkable degree of parallelism with the dykes. The dykes are regarded by the writer as having formed isolated basins, in which the solution altered the sedimentaries by replacement; hence the remarkably high grade of these ores in spite of their small extent. Detailed work in the vicinity of Jamda has proved the presence of three or four small deposits, along the fault mentioned previously. All along this fault are developments of cherts with more or less hematite, and, where the fault cuts sandy shales, which were more pervious than the general rock, pockets of hematite have been developed. These ores are usually of the laminated lateritic type. A similar ore mass has been noted to the north of Bokna, again associated with faulting. The Diraisum Buru deposits are also associated with extensive developments of breccia, and some igneous intrusion.

Thickness of the Ore-Bodies.—The question of the origin of the ores has an important bearing on the estimation of available tonnage of the field. Until some working hypothesis was formed, it was impossible to form any idea of the extension at depth of the ore. The amount of replacement has undoubtedly been enormous, and even if it be merely surface replacement there must be a very considerable tonnage. The porous beds appear to have been practically entirely replaced by ferric oxide, and much of the shale also. As the degree of replacement has been so intensive, it is exceedingly improbable that the ore masses will die out rapidly at depth ; particularly is this the case with those ore masses lying to the west of the fault running along the Saranda Range. To the west of the fault the width of the outcrop of the ore beds is really a measure of the thickness of the body. To the east the beds are more horizontal, and there is no indication of their true thickness. In certain places to the west of the fault the thickness of the ore masses outcropping is several hundreds of feet. To the east of the fault at least one ore mass measures 4,000 ft. across the outcrop, along the bedding plane at right angles to the general strike. There does not, therefore, appear to be any reason why, first, the extension down the dip to the west of the fault should not continue for several hundreds of feet, and, second, why to the east of the fault the thickness of the beds should not be comparable with the widths of outcrops to the west of the fault.

In the vicinity of Kondobond in Keonjhar State, bed after bed of massive granular ore is seen dipping regularly at an angle of about 45° to the south-east. Here there cannot be less than 450 ft. of vertical thickness of such beds. The same is true at Pachri Buru in Kolhan. At Sasangda vertical beds of at least 150 ft., consisting entirely or ore, are exposed on the western flank of the hill. For six miles along the range here ore outcrops along the whole length. This range is cut by three streams, at levels as much as 750 ft. below those of the outcrops on the summits, and in every case ore is found outcropping in the valleys. On the eastern flanks of the Saranda Range ore beds outcropping in the nullas are certainly not less than 500 ft., and may even be 1,000 ft., lower down the dip than the same bed outcropping on the shoulder of the hill. This would indicate that the ore extends at least 500 to 1,000 ft. along the dip in this locality.

The above examples will give some idea of the enormous extent and also probable thickness of the ore masses in this field. Undoubtedly many of the ore masses, especially those in the Upper Shales, are very thin, but the majority attain considerable dimensions.

Available Tonnage.—It is an extremely difficult matter in a virgin field like the present, in which no drilling work and very little mining work has been done, to give anything like reliable figures of tonnage. As pointed out in the preceding paragraph, the question of thickness is a very debatable one. Tonnages have been worked out for a number of areas and a minimum tonnage given. This has been arrived at by measuring the length and breadth of the outcrop, and by taking either a nominal thickness, of, say, 10, 20, or 50 ft., in cases where no indications of thickness were available, or by taking evidences of vertical exposure within the ore mass. The number of cubic feet taken per ton varies with the nature of the ore, and the presence of lateritic or shaly inclusions within the ore. In the case of the massive ores, 10 or 12 cubic feet have been taken as equal to one ton of ore in place. The theoretical figure would be in the neighbourhood of seven. In the case of the laminated and lateritic ores, 12 to 15 cubic feet have been taken, according to the local circumstances. It will be seen, therefore, that any error introduced is on the safe side. Again, it must be remembered that only those masses containing 60% or over of metallic iron have been regarded as ores. The lateritic ores in the Upper Shales, unless vertical exposures were found, have not been included in these figures, as it is recognized they may be very thin. The "detrital" and drift or float ores which would require pitting to prove have only been included where such evidence is available, and this is in not more than four cases. It will be therefore recognized that the minimum tonnage figures given are undeniably the irreducible minimum for the field. The figure for this field is estimated by the writer to be about 3,000 million tons of 60% and over metallic iron ore.

One eminent American iron and steel consultant on visiting a deposit, remarked : "This is not a mine ; it is a stock pile." Such a comment testifies to the richness of the field.

Comparison with the Lake Superior Ores.—A study of the monograph on the Lake Superior ores published by the Geological Survey of the United States, written by Van Hise and Leith, suggests that there are many points of similarity between the ores and associated rocks of these two fields. The taconites, jaspillites, and jaspers described and pictured by the authors are very similar to those met in the Indian field. In no case, however, have any "greenalite" or carbonate rocks been found in the Indian field.

By far the most significant similarity is the close association of the ores in both areas with extensive basic igneous rocks. The writer is of opinion that the origin of the ores in both these areas, while not identical, is due to the same causes acting under different geographical conditions.

Messrs. Van Hise and Leith writing on page 568 of the monograph, say: "The Lake Superior iron ores include the genetic types described in the following paragraphs. Lake Superior sedimentary type: Iron brought to the surface by igneous rocks and contributed either directly or indirectly by hot magmatic waters to the ocean, or later brought by surface waters under weathering to the ocean or other body of water, or by both; from the ocean deposited as a chemical sediment in ordinary succession of sedimentary rocks; later, under conditions of weathering, locally enriched to ore by percolating surface waters. To this class belong most of the producing ores of the Lake Superior region, those of the Michipicoten district of Canada and most of the non-producing banded iron-bearing formation belts of Ontario and Eastern Canada."

Again, on page 513 of the same monograph the authors state: "That the igneous rocks contributed some of their iron solutions directly to the water in which the iron-bearing sediments were being deposited is suggested by the fact that basic extrusive rocks have a widely developed ellipsoidal structure, which has been ascribed by many observers to submarine extrusion. If these lavas are submarine, then any iron salts extruded must have been contributed directly to the ocean. It will be shown in the following pages that if the salts were so contributed, simple and probable chemical reactions would develop the original greenalite or iron silicate phases of the iron-bearing formations. . . Further, the fact that iron-bearing formation seems to be lacking in association with certain similar greenstones in the Lake Superior region and Canada may be evidence that the iron-bearing formations derive their materials by direct magmatic contributions."

It will be seen, therefore, that the authors ascribe the same source of origin to the iron in the Lake Superior field as the writer in the present case, namely, the hot solutions from the basic igneous magma. The principal difference in the two cases is that while in the American instance the iron solutions were contributed direct to the waters and chemically deposited, in the Indian case the iron solutions found egress through faults to the relatively unconsolidated iron ore sedimentary series, and percolated along the bedding planes and through the porous strata, replacing the silica of the rocks by ferric oxide. That the conditions at the time of the basic intrusions in this field were terrestrial is suggested by:—

(1) The absence of any pillow lavas such as are found in Lake Superior, and the Hawaiian and Icelandic areas to-day;

(2) By the volcanic ashes discovered by Mr. H. Cecil Jones, of the Indian Geological Survey, in the Orissa and Chota Nagpur fields.

On page 516 of the monograph, Messrs. Van Hise and Leith write: "For the derivation of the unique thick and extensive iron-bearing formations of the Lake Superior region it is necessary to appeal to some further agency, other than ordinary processes of weathering, transportation, and deposition of iron salts. This is believed to be furnished by the large masses of contemporaneous igneous rocks. . . . The iron salts have been transferred from the igneous rocks to the sedimentary iron-bearing formations partly by weathering, when the igneous rocks were hot or cold, but the evidence suggests also that they were transferred partly by direct contribution of magmatic waters from the igneous rocks and perhaps in small part by direct reaction of the sea waters upon the hot lavas."

Similarly for the enormous extent of the Indian ores it is necessary to appeal to other agencies than ordinary weathering of rocks fairly rich in iron and their subsequent enrichment by surface waters. Besides, this cannot be applied in the present case, as associated shales in the iron ore series are remarkably free from iron. There is no doubt in the writer's opinion that these exceptional circumstances were supplied by the extensive basic intrusions that took place shortly after the deposition and uplift of the sedimentary series, which are now so richly iron-bearing.

Iron ores of an undoubted magmatic origin are found in both the American and Indian fields in the basic igneous rocks associated with the iron-bearing formations. For example, the titaniferous magnetites found to the south of Gurumahisani are undoubtedly magmatic segregations in dolerite. The titaniferous magnetites of the Duluth gabbro of northern Minnesota furnish an American example.

As would be anticipated from the foregoing, there are many points of similarity between the deposits of the two areas. The greater richness of the Indian field in quality and possibly extent is perhaps due to the fact that in the latter field there was a direct replacement of the beds by the solutions from magmatic sources, instead of the intermingling of chemical and mechanical sediments as in the American case.

CONCLUSION.—The foregoing account will emphasize the extreme value of the iron ore resources of India, which have hitherto not been considered in the world's reserves. These supplies are of high grade, and of such character that they can be cheaply mined and worked easily in the modern blast-furnace. Further, their relative proximity to the Indian coalfields (they are only 100 to 150 miles distant) renders them additionally valuable. There is no doubt that India, with these valuable natural advantages, must become one of the world's greatest iron-manufacturing centres in the near future. As yet the mining of these ores is still in its infancy, only two mines having up to the present been opened in the solid ore. With further work more evidence will be available for the geologist, and this field offers valuable opportunities for research.

CYANIDE HISTORY

By ALFRED JAMES, M.Inst.M.M.

The author gives reminiscences of the early days of the cyanide process, and voices the hardships of the inventor and the pioneer in introducing new ideas in metallurgy. This article takes the place of the author's usual yearly letter on gold metallurgy.

There seems but little progress to chronicle this year, and I have therefore decided to devote my annual letter to a consideration of what it really means to establish an improvement in practice.

A pioneer in volatilization work calls attention to the difficulty encountered by almost every keen enthusiastic inventor: that of finding sufficient financial support. A patent for however brilliant or useful an invention, is apt to be regarded by capitalists as a gamble rather than an investment. But the inventor is none the worse for having to rely mainly on his own resources, even for the development of a world-famous invention, such as that of Palissy the potter. It is indomitable keenness, proof against all discouragements, that develops grit and results of practical value.

History shows that the royalties derived from even the greatest epoch-making invention are usually but small recompense for the ingenuity, skill, patience, investigation, determination, cheery optimism, work, and capital expended in bringing the invention to a successful issue, and in, what is still more, forcing its adoption on a public which generally requires some years of education as to the advantages to be gained. Hence it happens that the fourteen years' protection on an epoch-making invention as a rule covers little more than the period of incubation, nursing, and developing to adolescent capacity.

Possibly the epoch-making inventions of the day are propulsion of vessels by steam turbines, radio-telegraphy, airplanes, and wave-transmission of power. To take the first. After fourteen years of incessant effort and skilful striving Parsons found himself at the end of his patent life with little more than his expenses. The history of Marconi is widely known. It was not until after many years of ceaseless ingenuity and untiring brilliant invention that the shareholders financing Marconi received a single penny on their money invested. The Wright brothers were never reported as entertaining Royalty or as marrying European princesses, and I understand Constantinescu has not yet received serious reward for the civil use of his inventions.

But, apart from the smallness of the remuneration, there is another feature that stands out strongly; that, but for the invincible enthusiasm and dogged determination of the inventor, every improvement would be the failure in practice it is at first almost universally pronounced to be by those learned in the art. It is, therefore, of the utmost value to the industry that the connexion of the inventor with the working of his invention should be obtained, maintained, and encouraged.

Professor Elihu Thomson says: "Publish an invention freely and it will almost surely die from lack of interest in its development. It will not be developed, and the world will not be benefited." It is essential that sufficient inducement be offered to obtain that fostering care which provides the main difference in results between many a successful process and previous attempts to accomplish the same purpose by similar or even well-nigh identical means. It is for this reason that so-called "anticipations" are pernicious. Disinterred from the dust and cobwebs of antiquity, unexplored except for the purpose of an action-at-law, they by-pass the main wealth and value of a patent, the toil, expense, skill, perseverance, and grit expended in its development. The "anticipations" were absolutely valueless from the lack of these adjuncts; ideas are cheap, it is work which develops fruitfulness. I hope to live long enough to see infringers thus relying on a prehistoric "anticipation" not merely treated with derision, but mulcted in a penalty for their failure to successfully employ, prior to the introduction of the contested invention which taught them the way, the anticipation they later bring forward as their defence in an action for infringement. Whence derived the infringers their valuable knowledge, from the patent or from the anticipations? The inventor to-day is unjustly treated; over the world the patent law is unfair to him on this point. A better plan might be to deal with an invention as with a copyright book, that is, reward the inventor for life with a small royalty from users; but the invention must first establish its novelty, and once established the State should uphold it.

Industry over the world must be made to realize the cost in time, money, skill, enterprise, courage, and keenness to develop successfully an epoch-making process, and thus I intend this year to deal specially with what should be now a matter of history, namely, the forcing on the industry of the cyanide process. Many inaccurate statements appear from time to time in the writings of learned men who have obtained at second-hand the history not within the scope of their own experience. I therefore published many years ago in the special twenty-first anniversary number of the *South African Mining Journal* an authoritative account from and substantiated by the official records. That account needs greater publicity.

One has to go back to 1886 to appreciate the effort of the parties mainly responsible, Messrs. Wright, Verel, and Gow, of the Cassel Gold Extraction Company. In that year this company found itself faced with the sudden disappearance of inventor and secretary and the collapse of a process which could not be made to work. The board of directors, undeterred by the flight of the inventor, determined to make the process work. It was found that the process, instead of being a cheap method of gold extraction, was in reality an expensive way of producing bleaching powder by the electrolysis of salt solution, to which lime was from time to time added. At this time Mr. J. S. MacArthur wrote an article to the technical Press showing how the process should be worked. The board therefore secured Mr. MacArthur's services, which resulted, however, in no improvement in results. MacArthur brought forward a little thing of his own, the extraction of gold ore by solutions of ferric chloride. But this method proved infeasible in practice.

Still undeterred and anxious to press forward the process, the board next investigated MacArthur's proposition of the use of solutions of cyanide of potassium; and now, with success apparently at hand, fresh difficulties and worries arose, only overcome by a display of such enthusiasm and bravery as but few men have shown under similar conditions either before or since. The board had already despatched an unsuccessful expedition, consisting of Messrs. Feldtmann and Arthur, to the mines of the St. John del Rey Company in Brazil to fulfil a contract entered into for the old process, and undismayed by the lack of result, resolved on sending out a number of expeditions to introduce the cyanide process and to educate the mining community to an appreciation of its advantages. The first expedition (Messrs. McIntyre) was sent to Queensland, the next to New Zealand (Mr. McConnell). From these two expeditions but little tangible resulted. Messrs. McIntyre demonstrated on concentrates and pyritic ores in iron pans, and Mr. McConnell erected a successful ore-treatment installation at Karangahake, but all this work attracted no users except for Dr. Scheidel's small concentrates plant at the Sylvia (1890).

The lack of success of these two expeditions, from the point of view of forcing a process on an industry or gaining adherents, in no way damped the ardour of the board. Before long a fresh expedition was planned to Africa (in the latter part of 1888), and a year later MacArthur was also sent off on an expedition to America. This latter expedition of MacArthur's was not a success. Indeed, it was not until some years later, after the process had accomplished great things in Africa and New Zealand, and Dr. Scheidel had proceeded from the latter territory to California, that the application of the process in Mexico and the success of cyaniding at Mercur, compelled the attention of the mining interests of the United States.

It will thus be seen that of four expeditions one only, the African, was successful in gaining adherents, and even then a further expenditure of time, money, and energy was necessary to force the process into general use.

Let us look into the history of the African introduction. A study will serve to show the enthusiasm, skill, courage, capital, and business energy necessary to convert even a successful demonstration into a general adoption. It fell to my lot to pioneer the process in South Africa. I arrived towards the end of 1888, and in accordance with my instructions at once proceeded to Lydenburg, Barberton, and the Horo mines in Swaziland, it being the intention of the board to demonstrate in either the first or last-named district. A visit to Barberton and my investigations at the United Pioneer (Moodies) decided Mr. J. H. Cordner-James to form a local syndicate, at the outset consisting of Messrs. J. M. Buckland, W. W. Webster, and himself, to acquire the African rights of the process. This step was the first real encouragement received by the keen and determined Scotsmen who had been so long pushing the process, and it undoubtedly was the cause of the subsequent demonstration being on so large and effective a scale.

From Barberton the pioneer came to the Rand, and after an examination underground, possible mainly owing to the extreme courtesy and kindness of the late Mr. Hermann Eckstein, of well-nigh every mine of note (over eighty) in the district, from the Nigel to Blaauwbank and Malmani, he settled down to conduct a series of experiments in an assay laboratory at the Langlaagte Estate, placed at his disposal, entirely without charge for laboratory, stores, or labour, by the liberality and shrewd foresight of Mr. (now Sir) J. B. Robinson. The investigations completed, I returned to Scotland to consult with my board as to the offer made by the local syndicate to purchase the South African patents. This was subject to the success of a public demonstration of the process to be held at Johannesburg, and having designed the necessary installation I brought it to Johannesburg early in 1890.

Meanwhile, one of those worries which daunt the most enthusiastic inventor cropped up in the matter of patent rights. On my original arrival in Cape Town I had found that Dr. Wernher von Siemens (represented in South Africa by Mr. E. Lippert) had a patent for a cyanide process, with electrical precipitation, dated only a month after the MacArthur–Forrest patent. Young and inexperienced, the writer did not deem it necessary to worry his board with such disquieting information, but decided on the spot to raise an action for the revocation of the Siemens patent. That such an action had never before been brought in the Colony, and that his attorneys proved also to be the Siemens attorneys, in no way disquieted him. His attorneys had to choose between the two clients and to proceed with the action. This step was most fateful to the future of the South African patents, for on his arrival at Pretoria he found that some local difficulty based on the difference between the Taal and High Dutch had caused the postponement of the acceptance of the MacArthur–Forrest application until a month after that of Siemens, who thus had prior rights in the Transvaal. Nothing daunted, a similar action—but with apparently less ground—was raised at Pretoria to that commenced at Cape Town, and a report made by letter to his board as to the condition of affairs found, and his consequent action.

The result is distinctly interesting; the Cape Courts decided in favour of MacArthur-Forrest, as the true and first inventors, and the Transvaal Court, although in this case Siemens had the prior date, decided to follow the decision of the Old Colony. The writer is informed that these were the two first patent actions in South Africa. On so little hung the fate of the introduction of the cyanide process into the Transvaal!

The demonstration plant, referred to previously, was erected by arrangement with the Salisbury Company at their battery. The enthusiastic encouragement given to the process by the then manager, Mr. R. A. Michell, is gratefully remembered by those who were naturally very appreciative of the slightest expression of approval in those early days. It is only fair to refer also to the attitude of the Press, and to the value of the publicity and encouragement freely and cheerfully extended to the pioneer of the process. Dormer of the *Star*, Rathbone of the *Mining Journal*, and Piet Davis of Maritzburg were towers of strength. They awoke the interest of the community, and, indeed, prepared the way for the subsequent adoption of the process. The writer has naturally much experience of the daily, the financial, and the technical Press in four of the five continents. Great publicity has been given at great length to his technical writings and to his work (whether he wished it or not), but never in all his professional career has he known of a single instance of payment for Press services so generously and spontaneously rendered.

By April, 1890, the demonstration plant at the Salisbury was ready for action, and early in May Mr. MacArthur, whose presence it was considered would be of especial value to the syndicate at this juncture, arrived at Johannesburg, and the demonstration took place, the writer having first run one hundred tons through the plant so as to have the staff acquainted with their duties and the plant running smoothly.

The success of the demonstration is well known. Later, in the year 1895, Mr. Hennen Jennings reminded me that the results then being obtained at the Crown Reef were just those obtained by him and Mr. J. R. Williams (afterwards famous for his successful method of treating slimes by decantation) in 1890 at the demonstration, but the fact remains that, except the manager (Mr. Michell) of the property on which the plant stood no one adopted the process!

This should be well considered and taken to heart by all persons fathering a new process, as it is just one of the difficulties by which an invention is faced. Practically every epoch-making invention is pronounced a failure at first, wherever exploited, and it is only the invaluable enthusiasm of the inventor and his financial associates which enables them to survive this blow and to ultimately force the process on the industry.

The Gold Recovery Syndicate who had contracted to purchase the patent rights thus found themselves, in the latter half of 1890, with no backing and no adherent other than Mr. Michell, but for whom they would have had the demonstration plant left on their hands. Mr. MacArthur had returned to Scotland, taking with him his cheque in payment of the plant, and it was left to the syndicate, with which was associated the writer, to take other and still more vigorous measures to force the adoption of the process. That these measures were taken is mainly due to the keenness and decision of Mr. W. W. Webster, who determined to spend his last penny, refusing to be discouraged, rather than fall short of complete success.

It was at this juncture that a Scotsman connected with one of the local banks came to our aid. Funds were thus obtained by which advantage could be taken of the liberal terms on which Hennen Jennings offered a block of valuable Robinson tailings, thereby enabling himself to obtain greater knowledge of the practical working of the process.

Up to this time the process had been described as for refractory ores and concentrates only. The demonstration was limited to the treatment of material of this nature. An installation was now designed by the writer for the treatment of tailings by percolation. This modification in the method of carrying out the process involved a change from the agitation of small charges in cylinders fitted with paddle agitators to the gravity percolation in large tanks of considerable quantities of material, and was so novel as to induce Mr. MacArthur's greatest friend on the Rand to state that the process was a new one and ought to be named jointly after Mr. MacArthur and myself, but this suggestion never appealed to me; the invention had been completely and thoroughly worked out by MacArthur and his associates; probably no invention has been placed before the public more completely and thoroughly worked out. The fact that the carrying out of the invention as originally put into practice in Australia, New Zealand, America, and South Africa had failed to induce a single adherent (other than Dr. Scheidel with his small concentrate plant at the Sylvia) to adopt the process made it obvious that our modus operandi was wrong. The adoption of gravity percolation made the process commercially successful, and of world-wide adoption, spreading from South Africa to New Zealand and India, with later adoption in the United States and in Western Australia, where inappropriate methods of introduction had caused a setback.

The new plant at Johannesburg was built by Messrs. Tarry in December, 1890, under the supervision of the writer, who laid down the plan of operations carried out by Messrs. Webster (manager), Gaze, and Darling.

The plant did not meet with the approval of the authorities in Glasgow, who had sent out a plan of a small (8 ft. by 6 ft.) square Tharsis tank as one to be followed, and it gave the writer no little satisfaction to be able to reply to a letter prognosticating failure with an account of the great success of the plant. Within two months of the commencement of operations the plant was showing a profit of over £2,000 a month on an original outlay of about £3,000, and the African Gold Recovery Company was formed and Mr. MacArthur was sent out by the new company to arrange for the local conduct of its operations.

But not even yet was the process forced on the industry. The new company decided to continue the profitable operation of the treatment of tailings on its own account. Fresh contracts were accordingly entered into with other companies, such as the Crown Reef and the Meyer and Charlton, and then at last the companies decided to adopt the process and the fight was won.

After five years' hard work, involving the training of many metallurgists, the erection of a cyanide-manufacturing works to prevent the supply of cyanide to the mines being restricted, the despatch of six expeditions, the fighting of two law-suits, and the carrying out of much chemical research, such as the use and effects of cyanide, alkalies, oxidizers, lead salts, alkaline sulphides, etc., and the manufacture of cyanide by various processes and the expenditure of over £100,000, an epoch-making process of the greatest success had been forced on an industry.

It is but a fair conclusion that but for the expenditure of so much dourness and determination, of so much patience and encouragement, of so much business common-sense and foresight, and last, but not least, of so much capital, the discovery of MacArthur and the Forrests, and of their financial associate, Morton, would not have been made available to the industry for many a year, but would have lain fallow as a non-pursued chimera with the unfollowed-up ideas of Faraday, Bagration, or the more practical processes of Rae and Simpson.

And what of the reward offered by the industry as remuneration for so much enterprise, effort, and success ? This question can scarcely be left to the industry. As to whether, after the result of the action taken by them, a result which, in view of the decision of the English Appeal Court, would have conceivably been different had the Transvaal been at that time a British colony, with right of appeal to the Privy Council, the mine-owners might have felt called on to make some remuneration to the patent owners who had so fostered the introduction of the process, one can understand that after the expense, worry, bitterness, and exhaustion of a prolonged fight, a feeling of relief at the result would predominate over all other feelings. But surely it behoves the industry in its own interest to see that the result of the challenging of the MacArthur–Forrest patent is not to deter other inventors from putting forward their methods in the Transvaal. Such a result appears to have already involved the Witwatersrand in an annual loss far greater than the royalty it would have paid had it not challenged the patent.

There is one other matter which arises from the consideration of the effect of the severing of the interest of the pioneer group in a new process. Those who have grown grey in the working of the new process may feel that they have not the prospect of a retiring pension for their old age. Such a thing might have been relied on had a pioneer company still continued its ownership to the usual period of patent expiry. Nine years ago I suggested that the greatest goldfield in the world could be large-hearted and could perhaps pardon a suggestion that a small contribution from the mines of a fraction of what they had saved in patent royalties would suffice to establish a fund, called, for instance, the Cyanide Pioneers' Pension Fund, from which all cyanide pioneers in charge of plants from, say, the earliest days of the process (first plants at each mine) who continued in the industry, not necessarily as cyaniders (they might have since become managing directors, consulting metallurgists, reduction officers, samplers, or assayers) might, on their retiring after twenty years' service, become entitled to draw a pension of, say, £300 a year for life. I regret that my proposition met with so little response on the part of the South African mine controllers. I trust to live long enough to see it adopted.

It has never been realized that the industry, the world over, has had the free use of an apparatus which has stood the test of time, and is still used practically unaltered, but which was designed for and first used on the Robinson tailings plant. This box could have been patented. Originally gold was precipitated from its cyanide solution by zinc shavings placed in chloride of calcium tubes; subsequently earthenware pots were used for a similar purpose. For the Salisbury demonstration plant teak boxes of four compartments were used, each compartment having a cast-iron box, with perforated bottom, which could easily be withdrawn to facilitate the cleaning-up operations for demonstration purposes. For the Robinson plant, however, this box of novel type was specially invented by me; it had a series of compartments with a space for the inflowing solution, which was conducted by a baffle to the bottom of a large compartment in which was placed an easily removable try on which the zinc shavings rested, and up through which the gold solution percolated, with a downward movement through baffle channels only. At the bottom of each compartment was a space for gold precipitate, and connected to the bottom of each compartment was a pipe, or channel, for drainage and cleaning-up purposes. For a generation that box, except that it is now frequently used in steel, has been well-nigh universally adopted for the recovery of the precious metal. A royalty of £20 a box—such as is freely given for a cone or tube-mill feeder—would not have been considered at all excessive. Probably ten thousand of such boxes have been used on the Witwatersrand alone; a small gratuity or recognition per box placed to the credit of a Cyanide Pioneer's Fund should have sufficed to make comfortable for the end of their lives those pioneers (first men on first plants of mines only) who may now find themselves seeking rest after their thirty years' toil.

[In answer to the Editor's inquiry whether something might be said on the subject of all-sliming in South Africa, Mr. James sends the following remarks, which we publish as an addendum to his foregoing article.]

At first glance, with many regrets for the limitations of personal experience, I should be tempted to ascribe pride of place to India for attention to the efficient condition of sump solutions and for zinc-box work; to the Rand for ore-crushing; to Australasia for filtration and agitation; and to America for mechanical efficiency in the handling of slime; and thus it seems all the more strange that in spite of the high level to which stamp-milling has attained on the Rand, the question should once more have arisen there of the abandonment of stamps and of the adoption of all-sliming. It has seemed to me that other districts have failed to adequately appreciate the results attained on the Rand through the special preparation of the ore for each stage of reduction so as to avoid the cushioning effect of material already sufficiently fine as well as the waste of power in choking a mill with products which should have been by-passed.

In my last Christmas letter I referred to the stamp-mills on the Rand and the ball-mills at Kalgoorlie as having given the highest return for horse-power and material expended.

It is obvious that in view of the consideration previously paid to this question on the Rand a new factor must have arisen there to account for this resurrection of the former proposals.

This new factor must be a change in the character of the ore; or in other words that the ore of the Far East Eand requires finer comminution for effective beneficiation than the more porous mineral of the Central Rand. Even so, the problem would appear to be simple of solution: (1) The cost of sliming the proportion of total ore, say, 40%, at present treated as sands; this cost was recently reported to be 1s. 9d. per ton actually slimed. (2) The added cost of the necessary equipment. (3) The increased gain resulting from all-sliming.

Formerly our investigations showed that the increased recovery obtained failed to compensate for the extra cost of sliming. With the ore of the Far East Rand the position may be reversed, but one cannot base figures on the difference between the recovery at present being obtained from sands and the increased recovery at present being obtained from slimes. In our experience we have found that reduction of clean quartz particles of "sand" to slime by no means yields the same recovery as that obtained from the, what I may term, natural slime, of an ore, the softer vein material, which may be clay, decomposed iron, and pyrites.

But if we can rest assured that the sliming of these clean quartzose particles—and it is just these slimed sand particles which offer most trouble to slime treatment, as they require more power in the agitators, and are apt to pack in the filter vats—does yield an additional extraction even sufficient to cover the cost of the sliming, the smoothness and efficiency of the continuous handling by the all-sliming process is very attractive.

It may be taken that the present practice of the Rand consists of rock-breakers, stamp-batteries, tube-mills, Brown agitators, and vacuum filters, and that in a new plant the question would arise of the addition of Dorr classifiers, the substitution of some other apparatus than a stamp for breaking down the ore, and the adoption of counter-current plant for the agitator and filter equipment. The Rand has devoted itself very successfully to remarkably fine classification by means of special cones. It would be interesting to have this practice compared on the spot with that of the Dorr classifier; but it is difficult to suggest an effective substitute for a stamp-battery. The disc crushers suggested from a South African source have not impressed me as a serious rival. They have not yet been sufficiently proved and have these not also the disadvantage of incorporating in the pulp an inordinate amount of finely divided iron? This is a serious matter, not generally recognized. I was at some pains to publish many years ago some work of Professor Christy, in which he showed the destruction of cyanide caused by the presence of such finely-divided iron in the pulp. More popular substitutes are Chilean mills, used with success in Mexico, and ball-mills of the Hardinge, Grusonwerk, Marcy, and shortened tube-mill types; but the attempt to grind in tube-mills or in rod-mills material of, say, $1\frac{1}{2}$ in. diameter down to slime in one operation has not yet proved economically successful. But a stamp-mill plus tube-mills has to my mind proved itself superior to any combination yet brought forward. Probably the ultimate combination of the smallest number of stamps to the largest number of tube-mills has not yet been worked out. It depends on the power available, the ultimate fineness required, and the extraction most profitably realizable.

The question of counter-current plant will not, I think, ultimately prove attractive on the Rand, which already has so great an experience of decantation. A recent letter from Ontario advises a tendency there to consider the addition of a filter to counter-current plant. If filtration is to be adopted, what can be the advantage to counterbalance for the disadvantage of a huge bulk of solution to be precipitated or of circulating through the works of much unprecipitated solution? After all the African decantation process has the advantage of a definite ultimate settlement of the slime, but both the decantation and the counter-current processes do not carry extraction and recovery far enough.

THE MINING SCHOOLS OF AUSTRALASIA

By C. M. HARRIS, M.Inst.M.M.

The pioneers of the educational movement in mining in Australia and New Zealand in nearly all instances have been miners who were anxious to improve their knowledge in surveying, assaying, mineralogy, and geology. A few enthusiasts would meet together and, guided by one of their number who had been trained in one or more of these subjects, they would carry out some practical work and gradually absorb the theory of it. As the membership increased, an application would be made to the Mines Department for a lecturer either for full or part time. Thus, from small beginnings grew the celebrated Thames (New Zealand) and Ballarat (Victoria) Schools of Mines, whose students have earned high reputations not only in their own country, but also in England, South Africa, Burma, and America. Other schools, such as Christchurch, Bendigo, Charters Towers, Zeehan, and Kalgoorlie, have added their quota.

The influence of three men, who had an enthusiasm in their own subjects and a strong personal charm, has in no small degree contributed to this success. They were Professor Ulrich, at Otago University School of Mines, Professor Alfred Micah Smith, of the Ballarat School of Mines, and Professor Sir Edgeworth David, of Sydney University Mining School. In 1885, when the Otago University College decided to form a mining school, Professor Ulrich was made its director. He was a keen mineralogist and petrologist, and with Professor Black he trained a body of men who in their turn became directors of schools of mines, lecturers in mining, and also mine managers in various fields throughout New Zealand and Australia. As the demand came from miners for technical advice, these men were sent around to deliver lectures, give practical instruction in the use of the blowpipe and simple assays for gold and silver. It was in this way that the Thames School of Mines was started. The present State Mining Engineer of Western Australia is very proud of the fact that some of his students at that School now enjoy world-wide reputations.

The Ballarat School of Mines was also fortunate in having secured such a cultured English gentleman for its director in Professor Alfred Micah Smith, who had to leave England owing to chest trouble four decades ago. Those of his old students who read these notes will remember how for years his white-haired sister attended his lectures, to see that the Professor kept out of draughts and put on his coat and muffler when he left the class-room. This was the environment in which we, as students, absorbed the principles of chemistry, and, may I add, reverence for women. The discovery of Broken Hill with its silver-lead ores, created the demand for metallurgical chemists. The mines there absorbed the graduates as soon as they completed their course of training at Ballarat. In 1896 the discovery of telluride at Kalgoorlie called for metallurgical chemists. Broken Hill was requisitioned for experienced men, and several of the Ballarat School of Mines men came to Western Australia as metallurgists, and in many cases have become general managers of the mines. Thus the early metallurgical practice in Western Australia owed much to Professor Micah Smith. As time went on the riches of the Golden Mile and the opening up of new goldfield centres, attracted graduates of Schools of Mines from all parts of the world.

With the demand for technically trained men, the Australian Universities altered their engineering and science courses to include mining subjects. Sydney University added geology and chemistry to its civil engineering course, some of the latter subjects were deleted from the course, and mining graduates became specialists in geology. Such is the great personality of Professor Edgeworth David that there is hardly a geological survey or university in Australia in which there is not one of his students, as a professor, lecturer, or chief or assistant geologist. Then it is must be remembered that in the intervals of lecturing he became the great authority on artesian water supplies of Australia, and reached the magnetic south pole with the Shackleton expedition. He was the geological officer in the Mining Corps of the A.I.F. in France and Belgium, and now he is in Western Australia revisiting various districts for his magnum opus, "The Geology of Australia." With all his distinctions, Professor David, as he is still called, never fails to recognize the work of others. In a talk with the writer recently with reference to the pioneering work of Mr. H. W. Talbot, late Field Geologist of Western Australia, he remarked that he took off his hat to the man who with his assistant, Mr. de Courcy Clarke (now in the Chair of Geology in the University of Western Australia), had, despite privations from scarcity of water, shortage of food, and attacks by hostile blacks, done such valuable work. They had traced up to its source and mapped out the great artesian water basin under the Eucla-Nullabor plain, near the boundary between South and Western Australia. This will make millions of acres available for stock raising.

While Professor Ulrich, Professor Micah Smith, and Professor David have been the greatest teachers in mining schools, the influence of Professor Kernot is noticeable on the graduates of the mining school of Melbourne University, in that they specialize in his, the engineering, side. The South Australian University Mining School students, no doubt owing to the proximity to the silver-lead mines at Broken Hill, chose metallurgical chemistry, and were trained by Mr. Alfred Higgin (nephew of Professor Micah Smith), and the University now numbers among its graduates managers of base metal mines throughout Australia.

Kalgoorlie, being the newest School of Mines in Australia, has had the advantage of its situation in the centre of a big mining field, where students can get practical experience at all periods of their course. It has also the good will and assistance on its advisory council of technically trained mining engineers in charge of big mines. The School started off to train men working on the mines in subjects in which they were interested. The number taking up individual subjects has increased year by year, and the value of that training has been felt on the mines and plants, in the higher efficiency of the men in their own special branches. Kalgoorlie students, like those of other Schools of Mines, soon began to specialize in one subject; in this instance it was that taken by the Director, namely, mine surveying. It is hoped that other companies will follow the precedent made by the General Manager (himself a School of Mines man) of the Golden Horseshoe mine, where the surveyor and geologist was promoted to the position of underground manager. The Director of the Kalgoorlie School, Mr. Thomas Butement (of Otago University) and Mr. B. H. Moore (from South Australian University) have charge of the diploma courses in mining and metallurgy respectively. The metallurgical laboratory has a considerable advantage in its equipment for practical stamp - battery work, gravity concentration, fine grinding in various ways, leaching, flotation, etc., so that it gives the students much useful experience and ideas, which are supplemented by frequent visits to the treatment plants on the mines in the vicinity. The course taken by most of the students is for the diploma in metallurgy with the certificate in surveying added, and it covers at least four years, the subjects being as follow: Mathematics, mechanics, mechanical engineering, building construction, physics, mining geology, petrology, mine accounts and administration, engineering, chemistry and assaying, metallurgy, mechanical drawing, and surveying. To this must be added twelve months' experience in a mine or treatment plant, on which the student is required to write a thesis on some phase of the work before receiving the associateship.

An associate of the Kalgoorlie School of Mines, provided he has matriculated, may be permitted to complete the course for the B.E. mining degree at the University of Western Australia in two years. This course is one of five years, of which four are done at the University, while the fifth year, embracing mining, mine surveying, and metallurgy, is taken at the Kalgoorlie School of Mines. So far there have not been any graduates in this course, the preference being for the four years at the Kalgoorlie School. The experience on a mine, for one or more years, is taken before going on to the University. This is found advisable for practical and also financial reasons, in order to provide the funds necessary for the final year's training and experience before he takes his degree in mining engineering. The standard is a high one, and the men securing it should compare favourably with those trained in any mining school in the world. It is hoped that the first graduate in this subject in the "baby" University of Western Australia will be proud to say that he was a "digger" on the fields of France and Belgium, between his School of Mines and University courses. Such are the men who are now being trained to deal with more difficult problems, both technical and industrial, than we older men have had to face, and they will succeed.

The success of a man as a mining engineer or metallurgist depends not so much on the question of whether he was trained at a School of Mines or at a University. The quality of leadership has a very important bearing on this. What difference there is in the training may be that School of Mines men have to earn their living frequently at some branch of mining and metallurgy while doing their course. Naturally they know much more of the psychology of the men they have to handle later on. Whereas the University trained man has more culture, and can reach heights as an educationalist that are outside the scope of a School of Mines graduate.

LETTERS TO THE EDITOR

Identification of Cassiterite

The Editor:

SIR—With reference to the article on "The Characteristics of Cassiterite" that appeared in your October issue, I would suggest that columbite be added to the list of minerals likely to be mistaken for cassiterite.

Columbite is a frequent associate of cassiterite in Nigeria, and at times is difficult to distinguish from the latter mineral. The following particulars may be of interest:—

Composition.—(Fe Mn) $(Nb, Ta)_2 O_6$.

Specific Gravity.—The specific gravity of Nigerian specimens is about 5·6, showing that the mineral has not a high tantalum content.

Crystal Form.—Orthorhombic, usually in flat, glittering plates, and occasional needle-like prisms. Heart-shaped twin occasionally seen.

Colour. Black.

Streak.—Dark purplish. In powder on

vanning-shovel the mineral looks like very dark-coloured cassiterite.

Blowpipe Reactions.—These appear to rather resemble those of wolfram.

With reference to the last point, I would suggest that a much more characteristic test for wolfram is to fuse a little of the powdered mineral with sodium carbonate in a loop or spiral of platinum wire. Dissolve in hydrochloric acid in a porcelain crucible, and boil nearly to dryness. Dilute with water, and pour off the yellow solution of iron chloride, and a heavy yellow precipitate indicates the presence of tungsten. This precipitate dissolves readily in cold "Scrubbs' Ammonia," which is usually available, and the test, as far as I know, is absolutely conclusive. It can be readily made in the field with a small grain of the mineral.

A. Stanley Williams.

Jos, Nigeria.
November 23.

The Origin of Primary Ore Deposits

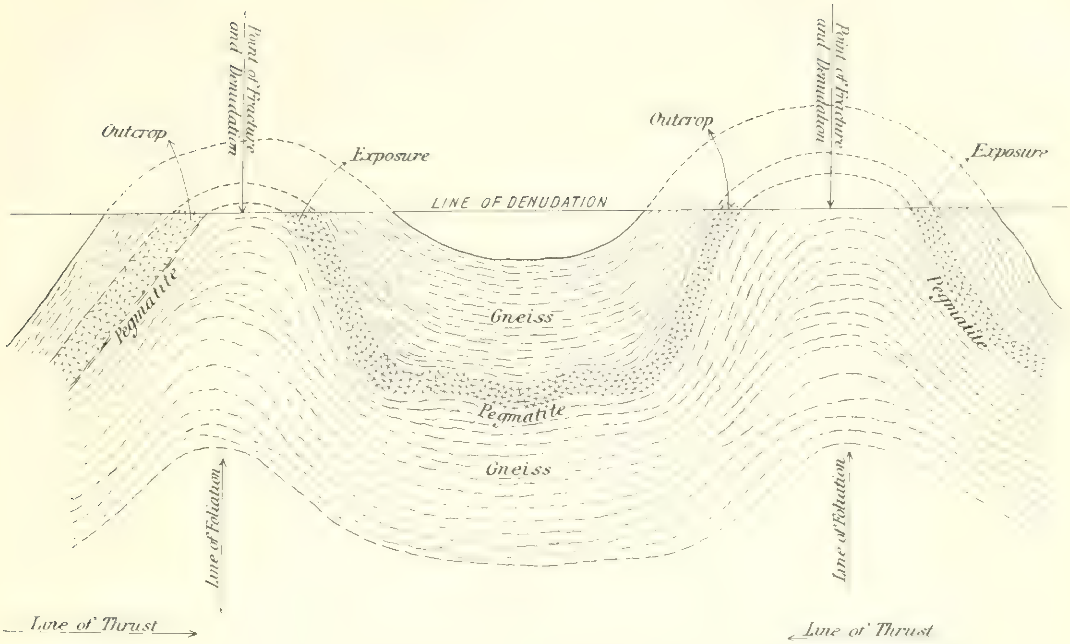
The Editor:

Sir—I have followed with great interest Dr. J. Morrow Campbell's paper on the Origin of Primary Ore Deposits, read before the Institution of Mining and Metallurgy last year, and also the contributions to the discussions thereon which have appeared in the *Bulletin* of the Institution and also in the pages of the Magazine, and I should like to contribute to this discussion and give my observations on some tin lodes in Nigeria.

The object of this communication is not to propound any theory, but only to offer some observations from actual experience in the ordinary course of a mining engineer's occupation. I made a cursory visit to Tavoy, Dr. Campbell's particular district, early in 1910, but for only such a limited period that after an interval of twelve years I would hesitate to offer any opinion on the subject, although I may have been one of the earliest mining engineers in that district. Dr. Campbell deals mainly with the occurrence of cassiterite and wolfram, whereas the following comments on certain deposits in Nigeria relate to an occurrence of cassiterite unassociated with wolfram. The general formation, however, is of such a character and the tin presents such peculiar features, that it may lend some interest to the discussion.

It has recently been my privilege to inspect and report on certain properties situated in the province of Ilorin, Northern Nigeria, and the information obtained serves to form an interesting comparison when the respective distance separating that country from Tavoy is considered. The cassiterite in question occurs in a very coarse holocrystalline pegmatitic formation, which has previously been described as a dyke formation. From examination, however, and from the results of prospecting operations over a long period and widely extended area, it would appear that the term "dyke" has been rather loosely applied. Geologically, I believe the term "dyke" may be applicable to a vertical or horizontal intrusion, though in the latter instance it more generally receives the term "sill." On the other hand, in referring to a dyke, a more or less vertical intrusion is visualized, having defined walls and definite strike and dip.

With regard to the formation now under review, systematic prospecting, costeaning, and trenching over a radius of many miles have failed to establish any intrusion displaying such continuity in any direction, or the characteristics associated with a true "dyke" formation. On the other hand, exposures of this formation are traceable over a distance of upwards of 50 miles in length and proportionately far in width. It consequently appears that this pegmatitic formation was not introduced as an intruded dyke formation, but rather laid down in the form of an extensive superficial "sill," its persistent occurrence in all directions being traceable at intervals over many miles. Cassiterite occurs in irregular and erratic patches throughout this formation. In some instances tourmaline is associated with it, and in other cases the two minerals appear quite independently. The occurrence of these minerals would appear to be ascribable to magmatic segregation, and on this supposition it may be supposed that in the fluid state the igneous magma covered a widely extended area, giving rise to the coarse holocrystalline matrix from which they crystallized out. The assumption that this magma was laid down in the form of a horizontal sill seems further borne out by the fact that the cassiterite in no instance holds down to any appreciable depth, and that sinking mainly exhibits a holocrystalline mass. At the same time, it seems to confirm Dr. Campbell's contention that the cassiterite was in some form an accompaniment of the igneous magma.



THEORETICAL SECTION ILLUSTRATING OUTCROPS AND EXPOSURES OF PEGMATITE.

From the description of the cassiterite given hereinafter, it would appear, however, that this mineral crystallized out after the cooling of the matrix, rather than contemporaneously ; otherwise it is difficult to account for the inclusion and total envelopment of quartz and mica in massive cassiterite specimens.

On the other hand, this would be explicable if, as suggested by Dr. Campbell, the igneous magma on solidification did give off an aqueous mother-liquor, conveying the bulk of the ore minerals, though under such circumstances a more even distribution of the cassiterite would be looked for rather than its occurrence in scattered and isolated patches.

Allowing the existence of this superficial sill, regional metamorphism has then played a part, as is exemplified by exposures of highly foliated gneiss through the shattered overlying pegmatite. This gives rise to apparently frequent independent outcrops of the pegmatite formation with intervening belts of varying width of the foliated gneiss, but these apparent repeated exposures of pegmatite would appear only to represent the upturned ruptured edges of the original overlying igneous magma and in no way form separate intrusions.

The country represents a series of undulating ridges of an abrupt or modified character according to the magnitude of the local metamorphic disturbance, and it will be readily understood how denudation and weathering have further had a modifying effect.

In the course of his paper Dr. Campbell states that " granitic magmas on solidification give off an aqueous mother-liquor. The primary crust was largely granitic, so we have to assume that it gave off a similar liquid. Such acid liquors invariably carry the bulk of ore-minerals originally present in the granitic magma, so we must assume that large quantities of ores were ejected at the surface of the primary crust. These would be mostly tin, tungsten, gold, copper, zinc, and lead. Probably none of these ore deposits has survived. They must have been denuded and dispersed in sediments and in aqueous solutions."

I have already tendered the suggestion that this formation prior to regional metamorphic action and subsequent tilting, represented a continuous superficial sill, and that the tin might consequently owe its deposition to a mother-liquor derived as suggested. Therefore, whether the formation be described as a superficial sill or treated in the light of a primary crust, whatever may be the objections to these assumptions, they certainly afford an apparently reasonable explanation for the occurrence of this formation and the cassiterite occurring in conjunction with it ; nor has it been entirely denuded and dispersed in sediments and aqueous solutions as Dr. Campbell considers probable. On occasion the shattered edges of the upturned pegmatite formation occur in such proximity that it has given rise to the speculation of a parallel dyke formation, or has been ascribed to faulting. But this peculiarity is more probably explained as previously set forth. There appears no indication or any lines on which the stanniferous portions of this formation can be systematically traced or followed. Cassiterite just "occurs" or, to employ an old adage, "where it is, there it is." On the other hand, frequent exposures of absolutely barren quartz occur and this synchronizes very closely with Dr. Campbell's preliminary paragraph on page 17 dealing with pegmatite.

The best indicator, if such a term can be ascribed to it, appears to be mica, whereas the predominance or presence of felspar proves the opposite. In fact, one might almost say the tin is principally confined to greisenized portions of the formation.

Referring further to page 17 of Dr. Campbell's paper, it may be noted that he states: "The solution that deposited this mixture must have been very concentrated, and, moreover, the process was completed in all probability in a very short space of time—days rather than years." In the instance with which I am dealing, however, the extremely coarse structure of the matrix and singular development of the cassiterite would appear to indicate that very deliberate cooling must have taken place.

Dr. Campbell further contends on page 22 that "the liquid on leaving the batholith carries, say, tin oxide and chalcopyrite in solution, its temperature falls as it passes upward, and at a certain point cassiterite commences to deposit and continues to do so upward until all the tin in solution is exhausted." With regard to the occurrence of cassiterite, to which my letter now refers, the tin in solution must presumably have passed upward, but has given rise to a purely superficial deposit not being traceable to any degree in depth or during its upward passage. One can only assume, therefore, that no marked alteration in temperature can in this instance have been registered in its transition from the batholith until its deposition on the surface, and to only a comparatively shallow depth. It would also appear questionable whether deposition must essentially have been engendered from loss of heat by the original fluid magma, when there are other factors which might throw certain of the constituents out of solution. If pressure in combination with heat are the accepted forces which produced and maintained fluidity of the original magma, reduction in pressure apart from fall in temperature might in itself cause certain components to crystallize out and disassociate themselves from the parent magma. The entire formation is also barren of any chalcopyrite, and, apart from tourmaline, any of those other minerals which form common associates with cassiterite.

On page 14 Dr. Campbell says: "The evidence in nature is overwhelmingly in favour of tin and tungsten having been transported in a silicic acid medium, and deposited therefrom by loss of heat, the same solution depositing quartz either simultaneously or at a later stage." The evidence relative to the formation at present under review would, however, point to the quartz having been deposited prior to the cassiterite, rather than subsequently, and not necessarily simultaneously. Further, although quartz is certainly almost invariably an accompaniment of tin, I cannot find that in this instance it is essential to its existence. Barren quartz is unhappily too often the sole reward of the prospector, whereas, if silicic acid is to provide the predominant medium of transition for all the metallic ores cited in Dr. Campbell's paper, then quartz, or whatever form in which it is subsequently deposited, should prove a welcome indication. The fact, however, is that it is of a far too universal occurrence to afford much serious indication at all.

Dr. Campbell states on the same page also that "both tourmaline and topaz alter to mica," but in this instance it is the felspar which gives rise to the mica, the tourmaline remaining unaltered.

Apart from the peculiarity of this geological formation is the singular character of the cassiterite itself, and this may have more bearing on the substance of Dr. Campbell's paper than the foregoing. The cassiterite itself occurs in patches and preponderatingly associated with the greisenized portion of the formation, though it might also appear to favour what might possibly be described as the shear planes of the shattered original magma, rather than any tendency to be disseminated throughout. It is also found as localized float in coarse crystals or massive and angular fragments disintegrated from the igneous matrix. In no instance does it possess alluvial characteristics, nor has it ever been derived in that form, which is perhaps a subject for some surprise. It occurs in widely separated and small isolated deposits which have produced from a few hundred pounds to four tons in the most productive instance.

Both the physical conditions and country itself oppose great obstacles to investigation, and one cannot help feeling that more extensive deposits than those located up to date may exist. Actual specimens exhibiting the following range of peculiarities represent the general characteristics of the cassiterite found, and I have never remarked in any other locality such singular peculiarities attaching to any deposit with which I am familiar :—

(1) Occurrence in the form of a " scale," as might be derived from a boiler. Some of these specimens exhibit polished surfaces as if they had been subjected to powerful shearing or friction as is observable on the faces of a slickenside.

(2) Specimens with rounded edges, as if the mineral had been subjected to a partial remelt after crystallization.

(3) Friable verging to earthy, which may, however, be purely attributable to weathering.

(4) Well-formed and grown crystals.

(5) Specimens exhibiting distinct " mould impressions " of the parent crystalline magma.

(6) Repeated corrugations as if crystallization had been alternately commenced and checked.

(7) Finally, the major proportion " massive " or crystalline, including quartz and mica embedded and fully enveloped in it, frequently not visible till fractured.

I am in possession of specimens illustrating all these peculiarities, and should be happy to show them and furnish any further information to anybody better qualified to express an opinion than my limited knowledge can afford.

Under any circumstances, in this instance unequivocal evidence exists from the foregoing examples that the cassiterite was formed subsequent to the complete or partial cooling of the igneous magma, but whether derived from gaseous, aqueous, siliceous, colloidal, or chemical sources is a matter for further investigation. I would suggest, however, that rather than seeking some abstruse explanation of these phenomena, it is possible that in common with nature generally some simple explanation may be found governing such occurrences, even as the fundamental laws of crystallography and other technical subjects are found to bear a simple relation to one another.

PERCY W. WHITEHEAD,
M.Inst.M.E., Assoc.Inst.M.M.

Ilorin, Nigeria, *September* 17.

The Editor :

SIR—I have read Mr. P. C. Whitehead's interesting contribution to the discussion on Dr. Morrow Campbell's recent paper [printed above] and have great admiration for the courage with which he enunciates an entirely new theory of the deposition of the Ilorin pegmatites. I disagree with Mr. Whitehead, however, on one point, but I do not do so in any spirit of carping criticism, rather as a co-worker in an attempt to advance our knowledge of a most interesting formation.

The contention in Mr. Whitehead's paper with which I join issue is that the pegmatites were laid down in the form of a superficial " sill."

I have never yet heard of pegmatite being deposited in this manner, nor can I discover any such instance in any well-known authority available to me ; this particular form of hypabyssal rock is usually regarded as of a nature intermediate in method of deposition between dykes and veins. If the pegmatite had been laid down as a superficial sheet over such a large area as 50 by 50 miles, it follows that the sheet would be of great thickness towards its point of origin, probably 500 ft., *at least*, and thinning down at a more or less rapid rate towards its limits. Observation in the field proves that this is not the case, as the average width of the intrusions over the above area is less than 8 ft., and I do not consider it possible for an igneous melt, ejected during the *last stages* of the cooling of granitic magma to preserve such a high fluidity, under conditions making for very rapid cooling, such as obtain at the surface, as to deposit a thin and comparatively regular sheet over an area of that extent.

I do not wish unduly to labour this point, but even granting what I consider to be an impossibility, the continued fluidity of the melt, it also follows from the above-mentioned comparative regularity of thickness, that if Mr. Whitehead's theory is correct, the ground level at the time of deposition must have been perfectly flat, or nearly so, otherwise "pools" of very variable thickness would fill up the depressions. This condition is too much to expect when the pegmatites were deposited as earth movements must have been severe.

It must also be borne in mind that if the pegmatite sill covers an area of roughly 50 miles in diameter when in a highly foliated condition, such as is shown in Mr. Whitehead's sketch, it would probably cover at least three times that area at the time of its deposition on comparatively level ground; that is to say, if the folds were flattened out, making it still more difficult for a fairly constant thickness to be maintained.

No "neck," "vent," or point of emission of the "sill" has yet been discovered. This is noteworthy, although not absolutely essential to the tenability or refutation of Mr. Whitehead's theory.

Mr. Whitehead attaches a sketch of a possible section in support of his "sill" theory. In my attached sketch (Fig. 1) it will be seen that I agree with him so far as the outcrops at the immediate surface are delineated, and am only at variance with him when he connects them with a series of synclines and anticlines.

I agree that, ignoring other considerations *re* thickness, etc., to which I have previously drawn your attention, the position of the surface as it exists and as it is shown in Mr. Whitehead's sketch, fits in with his theory of a foliated sill, but it *also* fits, as will be readily seen from my attached sketch, with the generally accepted dyke theory. It is fairly obvious, however, that in an area extending over 50 by 50 miles, the position of the surface relative to the folds of a sill would, under normal natural conditions, vary, cutting it in some places near the apices of the anticlines, which would then appear as superficial convex sheets (as at *A* in sketch), and at other points, at or near the bottoms of synclines, to form more or less shallow cups, troughs, or depressions of pegmatite (as at *B* and *C* in sketch). Prospecting over a large area, over very many outcrops, has located *no* such "hog's back" sheets or shallow troughs, although the workings have in many cases gone down as deep as 30 feet.

It will thus be seen from an inspection of my sketch, that only a surface horizon, which intersects the folds approximately midway in level between the upper and lower limits of sill foliation will fit in with the facts as observed in the field. Such an ideal horizon is delineated in Mr. Whitehead's sketch. On the other hand, a glance at my sketch will show that the dyke theory does not depend on an ideal horizon, any possible surface fitting in with the observed facts.

As a general rule, the pegmatites bend over as they near the surface (see sketch No. 2), the dykes becoming steeper at depth, but I am ignoring this in my large sketch, as the condition is purely surface and local, and due to disintegration. Possibly it is this surface curvature which has led Mr. Whitehead to suggest the foliated sill theory.

Turning to the aspect of the two cases which is of most interest to the mining engineer, the occurrence of cassiterite in the pegmatite matrix, I consider that the "sill" theory again falls short of what is demanded by the facts. If we take the case of two outcrops in close proximity, both tin-bearing and dipping in opposite directions, such as is shown in sketch No. 3, the most natural conclusion to draw would be that the denuded connecting anticline also at one time carried tin. This tin would surely show in the form of "float," continuous or fairly so, on the surface between the two outcrops, as it must be remembered that very little denudation has taken place in the district, all the cassiterite resulting from disintegration of the pegmatites being detrital and little travelled.

Here, again, experience does not justify the theory. The detrital tin is almost invariably only found in the immediate vicinity of the parent pegmatite, and in the extremely few instances where this is not the case my experience leads me to think that the dyke has so disintegrated and decomposed that it has practically disappeared in the overburden. There are many cases in which a yellowish discoloration in the subsoil or decomposed gneiss is the only remaining indication of the existence of a dyke.

Tin-bearing dykes are often found in close

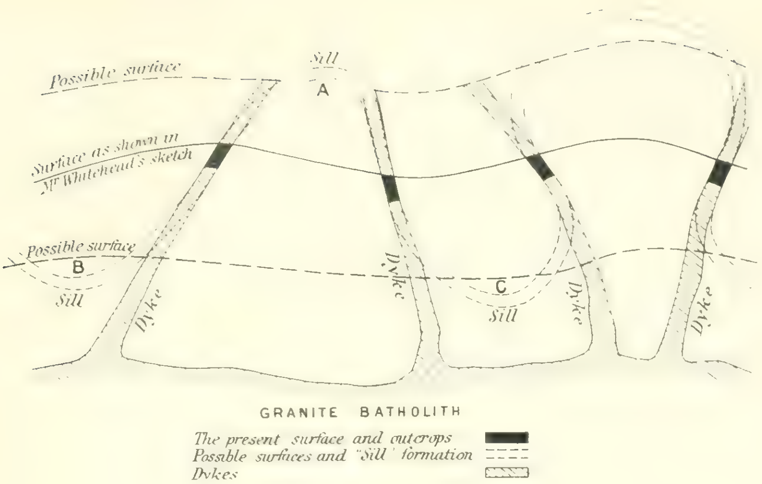


Fig. 1.

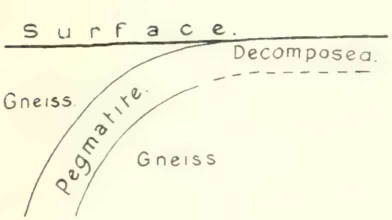


Fig. 2.

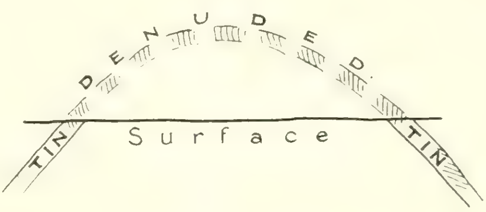


Fig. 3.

proximity, but it does not follow that if tin is found in one, all the prospector has to do is to follow the course of an imaginary anticline until it is again cut by the surface, and then another tin-bearing dyke will be found. Tin *may* be found in both, but in the absence of intervening "float" it is more reasonable to suppose that they are both ordinary dykes, have both been cut by the same "shear plane," and that the tin-bearing solutions have originated from a granite batholith under conditions which tended to comparative equality of temperature at the present surface, and consequently were both enriched at that point.

With the remainder of Mr. Whitehead's paper I am more or less in agreement. I am glad to see that he agrees with conclusions which I had previously arrived at independently, namely, that tin is usually, if not always, confined to the greisenized portions of the formation, that it is only found where felspar is absent, or nearly so, the latter having been probably converted to mica, and that it is secondary in order of deposition to the pegmatite, favouring the shear-zones. The quartz in the dykes is in a very much crushed condition (I have found only two well-crystallized specimens in two years), whereas the cassiterite often occurs in finely developed crystals enveloping the quartz. It would therefore appear that the pegmatite was subjected to great stress and crushing prior to the ascension of the mother liquors or gases which altered the felspar to mica and also deposited the cassiterite.

With Mr. Whitehead's statement that the cassiterite "appears to favour what might possibly be described as the 'shear planes'" I am in complete agreement.

A good example of this can be seen at Hanyan Iromo. At Hanyan Iromo, however, topaz was found in the same matrix as the tin, but towards the lower limits of the ore-body. This was an exceptional deposit, so I cannot disagree, in general, with Mr. Whitehead's statement that "the entire formation is also barren of . . . apart from tourmaline, any of those other minerals which form common associates with cassiterite." It is noteworthy, nevertheless.

It is also noteworthy that apatite, a common product of pneumatolytic action, was found in this deposit. The line of fracture up which the ascending gaseous or aqueous solutions had passed was clearly visible. It was filled with a very glassy, compact quartz, rather dark in colour, with exceptionally large crystals of cassiterite and topaz on its borders or aureole.

To any one who has had the opportunity of studying them, the Ilorin pegmatites, about which volumes might be written, present a problem of most fascinating interest, and I consider that the profession is greatly indebted to Mr. Whitehead for his presentation of the facts as they appear to him in such a lucid and readable form.

Donald K. F. MacLachlan.

Edinburgh.

October 12.

BOOK REVIEWS

Underground Conditions in Oilfields. By A. W. Ambrose. Bulletin 195, United States Bureau of Mines. Price 65 cents.

The purpose of this report, as indicated in the general statement, is "to point out the general method of procedure in studying underground conditions in oilfields and to place before the petroleum industry the results of proper co-operation between the so-called technical men and the practical men who have applied engineering methods to the development of oilfields." In this dual aim it may be said at the outset that the author has been most successful, though it is evident that there is still an enormous gap to be bridged before anything approaching ideal co-ordination between the self-trained oil man and the technical expert is attained. The general tendency on the part of the former individual is to regard the work of the technical man, be he engineer or geologist, with a suspicion almost amounting to contempt; this lack of harmony is dangerous in the long run, because neither geologist, driller, nor engineer is a self-contained unit on an oilfield, and the segregation of the various duties into water-tight compartments can only lead to unending trouble and defective methods of production.

Obviously the underground conditions in oilfields are primarily the geologist's affair; it falls to him to carry out the initial task of elucidating subterranean geologic structures in order that with the co-operation of the field manager or engineer the maximum production may be obtained from a given horizon; further, since a knowledge of such conditions depends on adequate sampling (a supremely difficult matter which many fail to realize), the utilization of the sympathetic services of the drillers is essential.

A study of underground conditions depends largely on the number and accuracy of available well logs extant for a given field; the fewer the wells, the less complete will be the knowledge of subjacent structures, though there are to-day many methods for arriving at certain likely conclusions on comparatively scanty evidence. Such methods include the intelligent interpretation of well records, the preparation of isobath maps of the producing horizons by means of convergent sheets, the use of progress charts, graphic representations, peg models, and stereograms; all these may be regarded as constituting the fabric of study on which the practical man may build his development policy, and the author of this report deals very concisely with these phases of the subject, and expands the results of such study in their application to the miscellaneous problems arising during oilfield evolution.

The discussion of these problems constitutes the most valuable portion of the book, more especially those in which water is the predominant factor, now universally recognized as being one of the most far-reaching and influential potencies in oil production. The question of water problems is very fully debated in this volume, and for this reason, if for no other, it commands attention. Opinion differs considerably as to the amount of time and labour necessary to the differentiation of various "waters" in oilfields; some technical men lay stress on the importance of closely studying the water conditions, while others are content to ignore them, trusting to chance in being able to "case off" obstinate water sands. There is little doubt that, as usual, the unscientific method abounds in pitfalls, and that the risks of flooding or complete failure are greatly increased by its adoption. The water sand should be regarded with the same care and circumspection as the oil sand; both should be well under control, if possible, and one should not be allowed to interfere with the other. An investigation of these water conditions comprises actual analyses of different waters as an aid to correlation of their natural reservoirs, thus differentiating top, middle, bottom, and edge waters. For tracing the movement of underground water various organic or inorganic dyes are used, such as fluorescein and potassium bichromate, and the author remarks on their value in some cases in the Californian fields. Other paragraphs deal with various field tests for water, methods of determination of the source of water in oil wells, the correction of wells making water, and the protection of oil sands by mud-flushing.

The report is profusely illustrated with tables, plates, and figures, and is a most commendable work, whose perusal is strongly advocated.

H. B. Milner.

Some Principles Governing the Production of Oil Wells. By C. H. Beal and J. O. Lewis. Bulletin 194, United States Bureau of Mines. Price 10 cents.

This publication, though small, contains much useful information on the behaviour of oil wells, and as an enunciation of the general principles involved, is a careful and lucid report. Many and varied are the factors controlling oil production during the life history of a well, the most important being the nature and extent of the producing sediment, its porosity, and the physical conditions under which gas, oil, and water may be co-existent within it.

Extraneous influences such as the effect of one well on the production of another are equally significant, and the authors discuss this in relation to the factors governing the decline of oil wells in general; careless spacing of wells without regard for subterranean conditions frequently leads to the interference of one source of supply with another, with consequent accelerated exhaustion of a producing well; it must be admitted, however, that an unwritten economic law frequently governs the spacing of wells in a given field, since the greatest possible production in the minimum amount of time and at the least expense defines the policy of the average producing company. Again, it is well known that the difference between the actual oil content of a sand and the ultimate production is often very great, the recoverable oil being estimated by some at only 5%; Lewis is quoted in this report as being of the opinion that only 10 to 20% of the oil is commonly extracted, though the authors state that 50% is the usual estimate. While conditions will vary from field to field, it is exceedingly doubtful in our opinion whether much more than 10% of oil is obtained on the average, and this is a point of great significance; it implies that even in the technique of drilling there is much room for improvement, and that modern methods of production have not yet reached a stage of finality. It is to publications of the present nature, at once practical, scientific, and constructively critical, that we look for guidance in the direction of increasing efficiency of oilfield operations, and we are once again indebted to the United States Bureau of Mines for a most valuable contribution to the literature of oil technology.

H. B. Milner.

Petroleum. A Monograph of the Imperial Institute, prepared jointly with the Petroleum Department with the co-operation of H. B. Cronshaw. Price 5s. net. London: John Murray.

This recently issued monograph on petroleum is one of a series published by the Imperial Institute dealing with the mineral resources of the world, with special reference to the British Empire, and as such it maintains that high standard characteristic of preceding volumes. For a long time past a small handy volume has been needed embodying the salient features of the geology, tectonics, and economics of the principal oilfields, and it is particularly gratifying to find that one of the few British publications on petroleum treats of the subject in a manner which leaves very little to be desired.

The book is divided into three chapters, the first dealing with the characteristics, occurrence, mining, refining, and production of oil, the two others embracing the world's resources, considered from the standpoint of the British Empire (and dependencies) and foreign countries respectively. The first chapter is necessarily a summary and treats of the subject matter in a non-technical fashion; it does not dilate on the more philosophical aspects of oil technology, rather leaning to a brief exposition of its more concrete essentials. Three useful diagrams are here included, showing at a glance the production of oil in tons from 1910 to 1918 in the chief countries of the world.

Passing to the sources of supply, we note that Great Britain is not made to figure largely as a "producer," either actual or potential; the government borings are, of course, mentioned, together with a typical result of the distillation of Hardstoft crude oil. The description of this well, with its seven barrels per day output, is, however, rather overshadowed by the succeeding table of requirements of this country, which, for the year 1919, amounted to nearly

3,000,000 tons. The Norfolk oil-shale field is passed over in discreet silence.

Besides the better-known producing countries, interest attaches to the less generally recognized possibilities in the British Empire (and mandated territories), including Sarawak, Palestine, Somaliland, and British Guiana, of which mention is made. Sarawak last year produced nearly 150,000 tons of oil or just half the total production of Trinidad for the same year; Palestine seems to offer little except solid petroleum products, as one would expect from its general geology and tectonics, though about 380 tons of asphalt per annum are exported from Beyrout; Somaliland certainly offers possibilities and an examination of the likely regions is now being carried out. In British Guiana a good deal of prospecting has been done, but the results have proved inconclusive; the Guiana Highland "block," a tectonic element related to the Brazilian shield, occupies too great an area in this country to make the chances of commercial oil production favourable.

Under the heading of foreign countries, the paragraphs of special interest are again the lesser known possibilities comprising China, Sakhalin, and Guatemala; in China the petroleum industry is incidental to the salt industry, an average production from the wells being 33% oil, 66% brine, obtained from the provinces of Shensi and Szechuan. The Sakhalin occurrences are in a belt of country bordering the Pacific coast of the northern half of Sakhalin, where the oil is associated with Tertiary sandstones; this is an area of which we shall hear more ultimately. Prospects in Guatemala depend entirely on observations of surface seepages, and such indications are frequently far from constituting a good augury of future supply.

The work includes statistics of production of the chief producing countries, together with a small oilfield map of the world, and concludes with a brief bibliography of petroleum literature.

H. B. Milner.

☞ Copies of the books, etc., mentioned under the heading "Book Reviews" can be obtained through the Technical Bookshop of *The Mining Magazine*, 724, Salisbury House, London Wall, London, E.C. 2.

The Rhodesian fossil skull, mentioned in our last issue, is to be the subject of a lecture by Dr. A. Smith Woodward, to be given at University College on January 24, at 5.30 p.m.

NEWS LETTERS

TORONTO

December 10.

Metallic Production of Ontario.—Returns received by the Ontario Department of Mines showing the output of the metalliferous mines and works for the nine months ended September 30, give the total value as $20,994,172, as compared with $35,920,418 for the corresponding months of 1920. This falling off is mainly due to the suspension of operations some months since by the International Nickel Co. There has also been a decrease in the production of silver, the output of which was valued at $4,382,520, as compared with $8,435,088. The production of gold shows a satisfactory increase, being $9,818,073, as compared with $8,735,768 for the first nine months of last year. Provided the output for the last quarter of the year equals that of the third quarter, the total gold production of 1921 will be approximately $13,870,000.

Porcupine.—All apprehensions as to a shortage of electric power such as occurred last winter have been allayed by heavy rains, which ensure ample supplies of power for the existing plants throughout the winter. But as regards the future, the question is one of vital concern to mining companies. The demand for electricity is steadily increasing, owing to the entering of new companies into the field, and the larger companies now operating are planning important extensions which they do not see their way to carry out until they can be assured of adequate supplies of power. Various power development projects have been considered from time to time, but no definite arrangement looking to an increase in the supply has yet been arrived at.

The McIntyre will proceed immediately with the installation of equipment which will increase its milling capacity from 550 to 800 tons daily. The new unit of 250 tons is specially designed to treat the carbonaceous ore occurring in the lower workings by the flotation process. The main shaft is down 1,875 ft. and new levels are being opened up at depth. Projects for further expansion are held in abeyance until the company can be certain of an additional supply of power. The Dome Mines has encountered some extremely rich ore in its lower workings. It occurs in an ore giving no visible evidence of gold, and yields assays of from $200 to $300 per ton. A similar ore found in the mines of West Australia indicates the presence of tellurides at depth, and it is believed that the rich material of the Dome may lie at the apex of a large gold telluride deposit. This view is supported by the fact that tellurides in limited quantities have already been found in some of the lower workings. At the Davidson Consolidated the drift on the 600 ft. level is in ore which assays $10·60 per ton across the width of the vein. Work is being carried on in preparation for sinking the new main shaft. A cross-cut on the second level of the Premier Paymaster has tapped a body of quartz porphyry about 98 ft. wide, containing fine sulphides. Channel assays show an average gold content of $5 per ton across the entire body. The Nipissing is making a thorough exploration by diamond drilling of the Rochester property, on which it holds an option, adjoining the Hollinger. It is stated that the results have been of an encouraging character.

KIRKLAND LAKE.—There are now five producing mines in this area, the mill of the Ontario-Kirkland having started operations about the end of November. It has a capacity of 100 tons of ore per day. The Lake Shore during October produced gold to the amount of $51,302 from the treatment of 2,015 tons of ore averaging $25·46 per ton. The shareholders of the King-Kirkland have approved an increase of the capital from $2,500,000 to $5,000,000 and the taking over of two adjoining properties known as the Ferguson claims which will give the company a total area of 389 acres. A modern mining plant is being installed. The reorganization plan of the Teck-Hughes has been approved by the shareholders. The capital will be increased from $2,500,000 to $4,000,000, and the unissued stock sold at 15 cents per share. The money raised will be applied to the payment of bonded indebtedness, and it is expected that the amount of the outstanding bonds can be reduced to $342,000, which it is proposed to meet from future earnings. Cross-cutting at the 500 ft. level of the Tough-Oakes has encountered two rich veins 6 and 7 ft. in width, stated to run $25 to the ton. They dip into the Burnside property. The Wright-Hargreaves has declared a dividend of 5%. The production is about $2,300 daily. Surface work on the Queen Lebel has resulted in uncovering a number of veins, one of which has a width of 4 ft. and yields assays of $20 per ton. At the Thackeray a shaft is being sunk on a well-mineralized vein about 6 ft. wide.

COBALT.—The production of the Nipissing during October shows a large increase, the estimated value of the ore mined being $258,768. Exceptionally rich ore has been recently developed. The La Rose will sink deeper on the Violet property, having met with satisfactory results at the 530 ft. level. A winze is being put down to 600 ft., and should results at that level be favourable, the main shaft will be sunk further. Operations on the Hudson Bay have been indefinitely suspended, and are not likely to be resumed. The future of the company will depend on the development of its holdings in the Kirkland Lake and Gowganda districts. The Coniagas during its year ending October 30 produced approximately 1,200,000 oz. of silver, nearly all from very low-grade ore. At the Oxford-Cobalt driving on the 75 ft. level has encountered ore carrying cobalt and leaf silver in encouraging quantities.

SOUTH LORRAIN.—The Mining Corporation of Canada has taken over on option the Haileybury Frontier, where ore has been opened up on the 150 ft. and 300 ft. levels. The Keeley mine has taken its place among the leading silver producers. During October its output was 102,819 oz. of which 36,819 oz. was in concentrates, and 66,000 oz. in high-grade ore. Ore reserves are estimated to contain approximately 850,000 oz. of silver.

VANCOUVER, B.C.

December 12.

MINERAL PRODUCTION OF 1921.—During recent years a preliminary estimate of the mineral production of the Province for the previous year has been issued by the Department of Mines sometime during the first ten days of the new year, but the Minister of Mines has decided that no preliminary estimate of this year's production is to be published, the excuse given being that of retrenchment. It is more likely, however, the real reason is that the value of the mineral production will show a decrease nearly 30% compared with that of last year, and, on account of the political renown attached thereto, the Minister is more prone to herald good news than what he thinks is bad. As a matter of fact, of course, the production is an exceedingly creditable one, when it is remembered that British Columbia is essentially a base-metal country, for the total output has decreased less than the total value.

Although no official figures will be available until next June, it is possible, owing to the fact that nearly all the production of copper has been made by one company and all the lead and zinc by another, to closely approximate the production of these metals from the smelter returns. The gold and silver, much of which is refined in the United States, cannot be so closely approached. I offer the following figures, however, in the belief that they will be as near to the actual production as a preliminary estimate can be expected to be. The values are obtained by multiplying the productions by the average values for the first 11 months of 1921 :—

	Amount	*Value in $*
Gold, oz. .	130,000	2,687,000
Silver, oz. .	2,800,000	1,751,400
Copper, lb. .	30,000,000	3,759,000
Lead, lb. .	45,000,000	1,939,500
Zinc, lb. .	50,000,000	2,555,000
Coal, long tons	2,080,000	10,400,000
Coke, do. .	70,000	490,000
Miscellaneous .		2,000,000
		25,581,900

VANCOUVER ISLAND COAL.— Two important appeal decisions recently handed down by the Privy Council vest the title to coal lands at Cassidy, Vancouver Island, with the Granby Consolidated M. S. & P. Co. These lands had been squatted on by settlers, and they, their heirs, or their assigns secured Crown grants, which were sold to the Granby company, and on which it developed and equipped a colliery and built a model village for its employees, at a cost of more than two and a quarter million dollars. The Nanaimo & Esquimalt Railway, a subsidiary of the Canadian Pacific Railway, sought to have the Crown grants set aside, claiming that the coal lands formed a part of the land grant that was deeded to the company by the Dominion Government in part consideration for the construction of the railway and that the Provincial Government had no right to issue Crown grants to the settlers. There were four test cases, and the Supreme Court of British Columbia decided all cases in favour of the railway company. The British Columbia Court of Appeal reversed three and sustained one of these decisions. The Privy Council has now decided all cases in favour of the Granby company. The decisions are doubly important in that they are test cases and will affect favourably 172 other cases that are on file for Crown grants of coal lands in the same district.

BRITANNIA BEACH DISASTER. — The coroner's jury on the bodies of those who lost their lives in the Britannia Beach disaster brought in a very drastic verdict, which said in part " The disaster was caused by what is known as the railroad fill, or dump, giving way, and we, the jury, declare that it was criminal neglect on the part of the Britannia Mining & Smelting Co., its manager, and its assistant manager, for deliberately allowing the blocking of a natural mountain stream, known as Britannia Creek." The jurymen's hearts probably ran away with their heads, for an investigation by an engineer instructed by the Provincial Department of Justice decided that there was no criminal neglect, a culvert 8 ft. square having been made for the passage of the waters of the stream, which was ample under any but very exceptional conditions. A phenomenal rainfall caused landslides in the higher reaches of the stream, forming a temporary dam, and when this broke, by the weight of water behind it, a quantity of debris was brought down and stopped the culvert in the railroad fill.

PREMIER MINE. — The Premier Mining Company recently shipped a third consignment of concentrate, totalling 250 tons, valued at from $1,500 to $1,750 per ton to the Tacoma smelter. The company is now making regular bi-weekly shipments of precipitate from its cyanide plant.

ROSSLAND.—A second shipment, consisting of two tons of bonanza ore and 20 tons of second-grade ore, has been made from the I. X. L. mine at Rossland. The two tons of bonanza ore yielded 296 oz. of gold and 47·5 oz. of silver, and the 20 tons of second-grade gave a return of 4·195 oz. of gold and 5·75 oz. of silver per ton. The first shipment of rather less than a ton of bonanza ore gave a return of 156 oz. of gold. The shoot from which this ore came is 8 to 10 ft. wide and 15 ft. long. It is being mined by a rise and a winze, the discovery having been made in the No. 3 level, and the roof of the rise and the floor of the winze is still in this same class of ore. The discovery has caused considerable excitement in the Rossland camp, and is likely to revive an interest in prospecting there.

PERSONAL

H. Standish Ball, lately with the Francois Cementation Co., has been appointed assistant general manager for the Apex Trinidad Oilfields, Ltd., and has left for Trinidad.

G. Canning Barnard is here from Mexico.

W. J. Barnett has returned from Canada.

Leslie Bradford, so long connected with the Broken Hill Proprietary, has started the electric manufacture of special steels at Waterloo, near Sydney.

Thomas B. Crowe, inventor of the vacuum process known by his name, has resigned as superintendent of the Portland mill, Colorado, and has gone to California.

J. G. Edwards has returned from Nigeria.

W. R. Feldtmann is back from West Africa.

H. Gemmell has left for West Africa.

Dr. J. W. Gregory, professor of geology in the University of Glasgow, is about to start on a tour of exploration in the mountains of Yunnan and western Sze-chuan.

Harold Hawkes has arrived from Australia.

Dr. J. A. L. Henderson has returned from America.

R. H. Johnson has returned from Nigeria.

Dr. Edward Fox Nichols, who was recently elected president of the Massachusetts Institute of Technology, Boston, has had to resign the position for reasons of health, and Elihu Thomson, the distinguished electrician, has been appointed as his successor.

H. E. Nicholls has left for Nigeria.

Wallington A. Pope has gone to Ilorin, Nigeria.

W. M. Thomas has left for West Africa.

Scott Thorn, representative of the American Cyanide Company, has returned to the United States.

P. A. Westgott has returned from West Africa.

J. H. G. Wilson has returned from West Africa.

H. R. A. Oertling, of the firm of L. Oertling, Ltd., makers of scientific balances, died on December 19, aged 73.

C. F. de Jersey Grut, a well-known West Australian mining engineer, died on November 2 after a brief illness. He was a graduate of Sydney University.

TRADE PARAGRAPHS

The Ingersoll-Rand Co., Ltd., of 165, Queen Victoria Street, London, E.C. 4, have been appointed sole agents in the British Isles for the Swedish Sandviken drill-steel.

The Hoffmann Manufacturing Co., Ltd., of Chelmsford, send us their latest booklet describing the application of their ball and roller bearings to mine cars, coal-cutters, electric motors, etc.

The Mitchell Conveyor and Transporter Co., Ltd., of Atlantic House, Holborn Viaduct, London, E.C. 1, send us a pamphlet describing the application of their system to coal and ash handling plants suitable for locomotives.

Edgar Allen & Co., Ltd., of the Imperial Steel Works, Sheffield, send us a new booklet, "Facts about Files." This pamphlet contains practical hints as to the importance of taking care of files, and gives details how to use them correctly and to choose the right file for each class of work. The illustrations are very helpful.

The Westinghouse Electric International Co., of East Pittsburgh, inform us that their Mr. H. C. Soule, who has for some time past been manager of their apparatus department, has left for their South American house at Buenos Aires. They also send us the current issue of their house organ, which contains among other things descriptions of hydro-electric plant at Lake Biwa, Japan, and of electric plant at the United Verde copper mine, Arizona. They further inform us that they have received an order from the Daido Electric Power Co., of Japan, for the electrical machinery for two large hydro-electric stations in the Tokio district.

The Hardinge Company, of New York (London office: 11, Southampton Row, W.C. 1), announce that they have acquired the pulverized fuel systems and engineering department of the Quigley Furnace Specialties, Ltd., and that this business will be operated as a department under the name of "Quigley Fuel Systems," with no change in the personnel. Also incorporated under the Hardinge Company is the Steacy-Schmidt Manufacturing Co., who make Ruggles-Coles driers and Keystone lime-kilns. The company has recently issued catalogues describing the application of the Hardinge mill to the pulverizing of cement and fuel; and also to the recovery of metal from waste, such as brass from foundry waste, aluminium from slags, etc.

METAL MARKETS

Copper.—Values of standard copper during December underwent little alteration, though on balance a slight loss was sustained. Demand from consumers in the United Kingdom continued rather dull, as was only to be expected with manufactured copper slow of sale, and the Continent, apart from Germany, did not take very much metal. A fair interest, however, was evident in the standard market on the whole. The news from the United States was encouraging, the price of electrolytic hardening at one time to about 14⅛ cents on an improvement in sentiment due to a betterment in home consumption, the more favourable statistical position, and a fairly lively inquiry from Germany. No sympathetic rise took place in the standard quotation in London, however, any such possibility being effectually negatived by the strength of the sterling exchange in New York, which subdued any tendency to bullishness which might otherwise have materialized here. The American position has taken a decided turn for the better, and with stocks dwindling appreciably there is now talk of a resumption of operations at various mines at present closed. One concern indeed has actually restarted. During the month, further purchases of rough copper were made here on American account, which assisted to reduce stocks in the United Kingdom. A good demand for scrap was seen, but refined descriptions were in poor request.

Average price of cash standard copper: December, 1921, £66 15s. 4d.; November, 1921, £66 13s. 6d.; December, 1920, £75 16s. 8d.; November, 1920, £84 18s. 6d.

Tin.—The general tendency in the London standard tin market during the past month was upwards, and although the highest level touched was not maintained, values closed at a substantial

Daily London Metal Prices: Official Closing
Copper, Lead, Zinc, and Tin per Long Ton

	Copper				
	Standard Cash	Standard (3 mos.)	Electrolytic	Wire Bars	Best Selected
	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.
Dec. 12	66 17 6 to 67 0 0	67 17 6 to 68 0 0	74 0 0 to 75 10 0	75 0 0 to 75 10 0	— —
13	66 12 6 to 66 15 0	67 12 6 to 67 15 0	74 0 0 to 75 10 0	75 0 0 to 75 10 0	67 10 0 to 69 10 0
14	66 12 6 to 66 15 0	67 12 6 to 67 15 0	74 0 0 to 75 10 0	75 0 0 to 75 10 0	— —
15	66 10 0 to 66 12 6	67 10 0 to 67 12 6	74 0 0 to 75 10 0	75 0 0 to 75 10 0	— —
16	66 15 0 to 66 17 6	67 15 0 to 67 17 6	74 10 0 to 76 0 0	75 10 0 to 76 0 0	68 0 0 to 70 0 0
19	66 15 0 to 66 17 6	67 15 0 to 67 17 6	74 10 0 to 75 10 0	75 0 0 to 75 10 0	— —
20	66 12 6 to 66 15 0	67 12 6 to 67 15 0	74 10 0 to 75 10 0	75 0 0 to 75 10 0	68 0 0 to 70 0 0
21	66 12 6 to 66 15 0	67 12 6 to 67 15 0	74 10 0 to 75 10 0	75 0 0 to 75 10 0	— —
22	66 5 0 to 66 7 6	67 5 0 to 67 7 6	74 10 0 to 75 10 0	75 0 0 to 75 10 0	— —
23	66 5 0 to 66 7 6	67 5 0 to 67 7 6	74 10 0 to 75 10 0	75 0 0 to 75 10 0	68 5 0 to 70 5 0
28	66 5 0 to 66 7 6	67 5 0 to 67 7 6	74 0 0 to 75 0 0	74 10 0 to 75 0 0	68 10 0 to 70 10 0
29	66 2 6 to 66 5 0	67 2 6 to 67 5 0	74 0 0 to 75 0 0	74 10 0 to 75 0 0	— —
30	66 2 6 to 66 5 0	67 2 6 to 67 5 0	74 0 0 to 75 0 0	74 10 0 to 75 0 0	68 10 0 to 70 10 0
Jan. 3	65 17 6 to 66 0 0	66 15 0 to 66 17 6	73 10 0 to 74 10 0	74 0 0 to 74 10 0	68 10 0 to 70 10 0
4	65 12 6 to 65 15 0	66 12 6 to 66 15 0	73 10 0 to 74 10 0	74 0 0 to 74 10 0	— —
5	66 0 0 to 66 2 6	66 17 6 to 67 0 0	73 10 0 to 74 10 0	74 0 0 to 74 10 0	— —
6	65 12 6 to 66 15 0	66 10 0 to 66 12 6	73 10 0 to 74 10 0	73 10 0 to 74 10 0	68 10 0 to 70 10 0
9	65 17 6 to 66 0 0	66 15 0 to 66 17 6	73 10 0 to 74 10 0	73 10 0 to 74 10 0	— —

advance. The firmness was due to no small extent to the fact that America came in as a purchaser on a fair scale, while furthermore the market was sustained by a regular demand from English tinplate works. Sentiment was remarkably optimistic on the whole in most quarters. Business with the Continent was moderate, Germany taking fair quantities. The Straits sold fairly regularly at prices only slightly above the London parity, while the rise in London also brought out some sales in Batavia and China. Rumours which had been current regarding the stocks of tin held by the Federated Malay States Government and the Dutch colonial interests, were dissipated by an authoritative announcement that these blocks of metal were to be held for five years if necessary rather than be liquidated at a loss; this naturally engendered further confidence in the position. While, of course, the revival in the British and American tinplate industries indicates that fairly large quantities of metal will be required for consumption in the near future, it cannot be denied that there is a plentiful supply of tin at the present time, and the situation hardly seems to justify any further rapid advance just yet.

Average price of cash standard tin: December, 1921, £169 16s. 10d.; November, 1921, £159 0s. 2d.; December, 1920, £212 11s. 8d.; November, 1920, £241 5s. 6d.

LEAD.—Values on the London lead market during December underwent moderate fluctuations. An easier tendency was in evidence at the beginning, this being in the nature of a reaction after the previous rise consequent on the shortage of supplies and the good Continental demand. Later, values became steadier, but the close of the month saw a renewal of weakness on account of larger arrivals from Spain. The latter country found itself obliged to divert shipments of lead to the United Kingdom originally intended for French consumption, owing to the Franco-Spanish customs dispute. This brought about a decided change in the market position here, and the easier state of supplies was clearly demonstrated by the disappearance at one time of the backwardation; that is to say, early delivery was obtainable at the same figure as forward, whereas for some considerable time past a substantial premium had ruled for the former. Business with consumers in the United Kingdom was quiet, although during the first part of the month quite a fair demand came out from the Continent; with the approach of Christmas and the New Year, however, inquiry naturally slackened off. Arrivals of metal from producing countries other than Spain continued to be of but moderate dimensions.

Average price of soft pig lead: December, 1921, £24 19s. 7d.; November, 1921, £24 4s. 10d.; December, 1920, £24 11s. 10d.; November, 1920, £32 5s. 6d.

SPELTER.—At the beginning of December, quotations had a rather easier tendency, but later a slight upward movement took place and a small advance was recorded on the month. The comparative firmness was due to the fact that supplies continued somewhat tight, very little fresh metal being offered by the various Continental producers, while America was not attracted sufficiently by the London quotation to sell here. Demand from galvanizers continued on a fairly satisfactory scale, though it was perhaps not quite so large as during the recent spurt in the galvanizing industry. The shortage was indicated by the steady decrease in stocks in the United Kingdom, and an inevitable consequence was a temporary advance in the spot quotation to the level of forward, the contango being thus abolished for the time being. Neither Norway nor Silesia appears to have any metal to spare for the London market at the moment, and Belgium has mainly asked prices above the parity of values here. The Belgian output, nevertheless, continues to expand, being over 6,000 tons in November, and if, as seems likely, this process develops, Continental interests may be more inclined to sell here. London is the cheapest market at the present time, and until supplies are more ample it is improbable that foreign makers will evince any eagerness to offer to this side, as prices are more advantageous on their own markets.

Prices on the London Metal Exchange.
Silver per Standard Ounce ; Gold per Fine Ounce.

Lead: Soft Foreign	Lead: English	Zinc (Spelter)	Standard Tin: Cash	Standard Tin: 3 mos.	Silver: Cash	Silver: Forward	Gold	
£ s. d. £ s. d.	£ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	d.	d.	s. d.	Dec.
25 15 0 to 25 2 6	27 0 0	26 12 6 to 27 0 0	171 5 0 to 171 10 0	173 0 0 to 173 5 0	35[illegible]	35	98 10	12
25 10 0 to 24 15 0	27 0 0	26 12 6 to 26 18 9	169 15 0 to 170 0 0	171 10 0 to 171 15 0	34⅞	34⅜	98 2	13
25 12 6 to 24 17 6	27 0 0	26 17 6 to 27 7 6	170 0 0 to 170 5 0	171 15 0 to 172 0 0	35¾	35⅝	98 9	14
25 15 0 to 24 17 6	27 0 0	27 5 0 to 27 12 6	174 10 0 to 174 15 0	176 10 0 to 176 15 0	35⅛	34¾	98 1	15
25 12 6 to 24 15 0	27 0 0	27 7 6 to 27 12 6	174 10 0 to 174 15 0	176 5 0 to 176 10 0	35[illegible]	35¾	98 10	16
25 10 0 to 24 12 6	27 0 0	27 12 6 to 27 15 0	172 10 0 to 172 15 0	174 10 0 to 174 15 0	35[illegible]	35⅛	98 1	19
25 10 0 to 24 12 6	27 0 0	27 10 0 to 27 12 6	171 10 0 to 171 15 0	173 5 0 to 173 10 0	35⅞	35⅝	97 8	20
25 7 6 to 24 10 0	27 0 0	27 7 6 to 27 10 0	171 7 6 to 171 10 0	173 5 0 to 173 7 6	35½	35¼	97 7	21
25 5 0 to 24 12 6	27 0 0	27 7 6 to 27 7 6	170 15 0 to 171 0 0	172 15 0 to 173 0 0	35⅛	34[illegible]	97 9	22
25 0 0 to 24 7 6	26 10 0	27 7 6 to 27 7 6	171 0 0 to 171 5 0	172 17 6 to 173 0 0	34⅞	34¾	98 1	23
24 8 9 to 24 3 9	26 0 0	27 7 6 to 27 7 6	172 5 0 to 172 7 6	174 5 0 to 174 7 6	35⅓	34[illegible]	97 10	28
24 2 6 to 24 2 6	26 0 0	27 5 0 to 27 5 0	170 15 0 to 171 0 0	172 15 0 to 173 0 0	35[illegible]	35	98 0	29
24 7 6 to 24 2 6	26 0 0	27 2 6 to 27 5 0	170 10 0 to 170 15 0	172 10 0 to 172 15 0	34¼	34[illegible]	98 0	30
								Jan.
24 7 6 to 24 5 0	26 0 0	27 7 6 to 27 12 6	168 12 6 to 168 15 0	170 10 0 to 170 12 6	34½	34[illegible]	97 9	3
24 5 0 to 24 5 0	26 0 0	27 7 6 to 27 10 0	167 12 6 to 167 15 0	169 12 6 to 169 15 0	34⅞	34[illegible]	97 9	4
24 7 6 to 24 7 6	26 0 0	27 0 0 to 27 7 6	167 12 6 to 167 15 0	169 12 6 to 169 15 0	34½	34[illegible]	98 4	5
24 10 0 to 24 7 6	26 0 0	27 2 6 to 27 10 0	167 15 0 to 168 0 0	169 15 0 to 170 0 0	34[illegible]	34[illegible]	97 11	6
24 7 6 to 24 7 6	26 0 0	26 17 6 to 27 5 0	163 15 0 to 167 0 0	168 15 0 to 169 0 0	35½	35[illegible]	97 6	9

The American position is reported to be improving, and so far the rise in the sterling exchange has not brought out any appreciable sales from that quarter. The scheme to restart various English works has materialized to some extent, a few plants having resumed operations.

Average price of spelter: December, 1921, £27 0s. 11d.; November, 1921, £26 4s. 10d.; December, 1920, £28 11s. 6d.; November, 1920, £35 14s. 7d.

Zinc Dust.—Quotations are nominal and unchanged. Australian high-grade £50, American 92 to 94% £47 10s., and English 92 to 94% £45 per ton. Continental material is quoted at £40 to £45.

Antimony.—The market is colourless, with values steady. English regulus £34 to £37 per ton for ordinary brands, and £35 5s. to £39 for special brands. Foreign is obtainable at £24 10s. in warehouse for home consumption, with as low as £22 f.o.b. accepted for export orders.

Arsenic.—Cornish white, 99%, is easier at £40 per ton delivered London; this price is rather nominal.

Bismuth.—The quotation is unchanged at 7s. 6d. per lb.

Cadmium.—The market has eased slightly, holders now asking 5s. 9d. to 6s. per lb.

Aluminium.—Business is quiet, with domestic producers quoting £120 for home and £125 for export. Foreign metal is obtainable at around £92 10s. f.o.b. Continent.

Nickel.—The tendency is easier, English makers now quoting £180 per ton for both home and export business, while foreign material is about £175 per ton.

Cobalt Metal.—Sellers still ask 14s. per lb.

Cobalt Oxide.—There has been no change, black being priced at 10s. 9d. and grey at 12s. per lb.

Platinum and Palladium.—Quotations are unaltered as follow: Manufactured platinum £19 10s. per oz., raw £18; manufactured palladium £19 10s., raw £13 to £14.

Quicksilver.—The market is dull, with the quotation for spot material practically unchanged on the month at £10 7s. 6d. to £10 10s. per bottle.

Selenium.—Powder is steady at 9s. 6d. per lb.

Tellurium.—Sellers ask 70s. to 80s. per lb.

Sulphate of Copper.—The price is fairly steady at £28 per ton for both home and export business.

Manganese Ore.—The market is steady, and Indian grades are selling at 1s. 1½d. to 1s. 1¾d. per unit c.i.f.

Tungsten Ore.—Dull around 11s. 6d. per unit, c.i.f., for 65% WO_3.

Molybdenite.—The position is weak, and the price of 85% nominal at 30s. per unit c.i.f.

Chrome Ores.—The tendency has been downwards, sales being effected at £4 c.i.f.

Silver.—Spot bars opened the month on December 1 at 37⅝d., only to slump to 34½d. on the 8th. The quotation then improved to 35½d. on the 10th, fell to 34⅞d. on the 13th, rose again to 35¾d. on the 14th, weakened to 35⅛d. on the 15th, advanced to 36⅜d. on the 17th, and then reacted once more to 34⅞d. on the 23rd. The price closed at 34⅝d. on December 31. The weak undertone of the market was due to lack of support, China apparently neglecting the London market in favour of San Francisco, where she bought instead, while the little Indian demand in evidence was unable to sustain values.

Graphite.—Business is dull, and quotations somewhat nominal. Sellers ask £20 to £25 per ton for Madagascar 80 to 90 per cent.

Iron and Steel.—A factor of interest during the last month was the reduction in English and Welsh railway rates, but these were so inadequate that little benefit is likely to ensue. They are, however, a step in the right direction. Meanwhile, pig-iron production is very restricted, owing to high costs, and the fact that present prices militate against an increase in demand. No. 3 Cleveland stands at 100s. per ton. In manufactured materials the outlook is brighter, as sacrifices have been made in the form of selling below cost for export, and quotations are now not far above those quoted by the Continent.

STATISTICS

PRODUCTION OF GOLD IN THE TRANSVAAL.

	Rand	Elsewhere	Total	Price of Gold per oz.
	Oz.	Oz.	Oz.	s. d.
November, 1920 ..	618,525	15,212	633,737	117 6
December	617,549	14,666	632,215	115 0
Total, 1920	7,949,038	204,587	8,153,625	—
January, 1921 ...	637,425	14,168	651,593	105 0
February	543,767	14,370	588,137	103 9
March	656,572	14,551	671,123	103 9
April	665,309	16,073	681,382	103 9
May	671,750	16,026	687,776	103 9
June.............	663,383	15,107	678,490	107 6
July	673,475	16,080	689,555	112 6
August..........	695,230	16,296	711,526	111 6
September.......	674,157	16,939	691,096	110 0
October	690,348	17,477	707,825	103 0
November	688,183	16,053	704,236	102 0

NATIVES EMPLOYED IN THE TRANSVAAL MINES.

	Gold mines	Coal mines	Diamond mines	Total
November 30, 1920 ..	158,773	14,245	3,504	176,522
December 31	159,671	14,263	3,340	177,274
January 31, 1921 ...	165,287	14,541	3,319	183,147
February 28	171,518	14,697	1,612	187,827
March 31	174,364	14,906	1,364	190,634
April 30	172,826	14,908	1,316	189,050
May 31	170,595	14,510	1,302	186,407
June 30	168,152	14,704	1,317	184,173
July 31	166,999	14,688	1,246	182,933
August 31	169,008	14,446	1,207	184,661
September 30	171,912	14,244	1,219	187,375
October 31	175,331	13,936	1,223	190,490
November 30	176,410	13,465	1,217	191,092

COST AND PROFIT ON THE RAND.

Compiled from official statistics published by the Transvaal Chamber of Mines.

	Tons milled	Yield per ton	Work'g cost per ton	Work'g profit per ton	Total working profit
		s. d.	s. d.	s. d.	£
Nov., 1920 ..	1,799,710	40 2	26 3	13 1	1,255,749
December ...	1,797,970	39 11	26 8	13 3	1,193,672
January, 1921	1,895,235	35 0	26 3	8 9	829,436
February	1,575,320	35 6	28 6	7 0	550,974
March	1,958,730	34 5	26 1	8 4	813,636
April	1,991,815	34 5	25 10	8 7	854,533
May	1,955,357	35 3	26 2	9 1	889,520
June	1,966,349	35 10	25 10	10 0	979,769
July.........	2,010,236	37 2	25 7	11 7	1,163,565
August	2,050,722	37 3	25 4	11 11	1,226,282
September ...	1,997,086	36 8	25 2	11 6	1.151,127
October......	2,041,581	34 4	24 9	9 7	981,597

PRODUCTION OF GOLD IN RHODESIA.

	1919	1920	1921
	£	oz.	oz.
January	211,917	43,428	46,956
February	220,885	44,237	40,816
March	225,808	45,779	31,995
April	213,160	47,090	47,858
May............	218,057	46,266	48,744
June	214,215	45,054	49,466
July	214,919	46,208	51,564
August	207,339	48,740	53,200
September	223,719	45,471	52,436
October	204,184	47,342	53,424
November	186,462	46,782	53,098
December	158,835	46,190	—
Total ...	2,499,498	552,498	535,557

TRANSVAAL GOLD OUTPUTS.

	October		November	
	Treated Tons	Yield Oz.	Treated Tons	Yield Oz.
Aurora West..........	10,130	£13,872*	10,723	£14,181†
Brakpan	58,000	22,435	57,900	23,338
City Deep	90,600	37,097	86,500	34,603
Cons. Langlaagte	45,100	£68,099*	45,000	£66,692†
Cons. Main Reef	50,000	17,538	50,000	17,793
Crown Mines..........	198,000	59,831	171,000	55,758
D'rb'nRoodepoortDeep	27,000	9,600	27,000	8,784
East Rand P.M.........	127,000	33,270	124,500	30,243
Ferreira Deep	32,500	10,076	33,100	10,431
Geduld...............	46,500	17,282	46,000	17,363
Geldenhuis Deep	47,321	12,591	48,777	12,941
Glynn's Lydenburg ...	4,003	£8,069‡	3,600	£6,752§
Goch	17,200	£19,544*	16,500	£18,517†
Government G.M. Areas	140,000	£309,087*	140,000	£319,903†
Kleinfontein	51,000	13,912	48,000	13,123
Knight Central........	28,500	6,572	30,000	6,707
Langlaagte Estate	43,600	£69,020*	45,000	£69,160†
Luipaard's Vlei	21,160	£23,860*	18,760	£20,360†
Meyer & Charlton	14,500	£43,133*	14,600	£43,076†
Modderfontein, New ..	107,000	49,278	108,000	50,391
Modderfontein B	59,000	30,661	59,000	30,095
Modderfontein Deep. ..	43,300	24,119	43,300	23,728
Modderfontein East....	27,000	9,724	24,600	10,366
New Unified	11,200	£13,488*	11,700	£13,142†
Nourse	44,500	14,767	45,800	15,527
Primrose	21,000	£23,326*	22,500	£24,621†
Randfontein Central ..	118,500	£180,830*	121,000	£179,327†
Robinson.............	40,200	7,989	39,500	8,112
Robinson Deep	61,300	19,167	60,500	20,040
Roodepoort United ...	20,500	£20,663*	17,650	£18,785†
Rose Deep	57,700	13,977	55,060	13,879
Simmer & Jack	60,000	13,941	60,000	14,632
Springs	41,400	17,507	45,000	18,913
Sub Nigel	10,200	5,810	10,400	5,994
Transvaal G.M. Estates.	16,040	£27,659‡	14,330	£21,906§
Van Ryn	33,300	£47,990*	32,600	£46,883†
Van Ryn Deep	53,400	£151,944*	55,400	£150,826†
Village Deep	53,200	16,759	51,100	16,216
West Rand Consolidated	34,100	£46,974*	33,000	£44,878†
Witw'tersr'nd (Knights)	40,500	£52,266*	42,700	£55,237†
Witwatersrand Deep ..	33,170	9,785	35,000	10,036
Wolhuter.............	33,200	8,065	31,200	7,673

* Gold at £5 3s. per oz. † £5 2s. per oz. ‡ £5 1s. 6d. per oz. § £5 0s. 3d. per oz.

RHODESIAN GOLD OUTPUTS.

	October		November.	
	Tons	Oz.	Tons	Oz.
Cam & Motor	13,000	4,823	14,200	4,970
Falcon	15,890	2,925‖	15,671	2,882*
Gaika	4,181	1,400	4,002	1,489
Globe & Phœnix	6,241	6,061	6,139	5,970
Jumbo	1,650	505	1,450	500
London & Rhodesian ..	3,554	£4,135	3,283	£4,301
Lonely Reef	5,100	4,610	5,200	5,024
Planet-Arcturus	6,010	2,530	—	—
Rezende	5,800	2,761	5,850	2,845
Rhodesia G.M. & I. ..	310	316	—	—
Shamva	56,600	£42,129§	60,100	£39,692‡
Transvaal & Rhodesian	—	—	1,610	£5,345†

* Also 259 tons copper. † At par. ‖ Also 275 tons copper. § Gold at £5 2s. 6d. per oz. ‡ Gold at £4 17s. 6d. per oz.

WEST AFRICAN GOLD OUTPUTS.

	October		November	
	Tons	Oz.	Tons	Oz.
Abbontiakoon	7,760	£11,699*	7,100	£11,571*
Abosso	6,275	2,547	6,303	2,556
Ashanti Goldfields	7,537	7,012	7,503	6,943
Obbuassi	662	£3,720†	693	£2,714†
Prestea Block A.......	7,220	£11,953*	6,704	£10,704*
Taquah	3,270	2,085	3,320	2,116

* At par. † Including premium.

West Australian Gold Statistics.—Par Values.

	Reported for Export Oz.	Delivered to Mint Oz.	Total Oz.	Par Value £
March, 1921	10	47,875	47,885	203,401
April	607	46,602	47,209	200,635
May	474	47,638	51,503	217,495
June	153	28,194	28,347	120,410
July	1,641	44,917	46,558	197,774
August	110	51,731	51,841	220,205
September	380	50,728	51,108	217,092
October	1,910	51,286	53,196	225,959
November	156	46,429	46,585	197,879
December	451	53,348	53,799	228,522

Australian Gold Outputs.

	West Australia	Victoria	Queensland	New South Wales
1921	oz.	oz.	oz.	£
January	51,458	4,587	4,582	20,463
February	27,557	10,940	9,046	21,575
March	47,886	12,383	6,690	24,344
April	47,273	5,954	2,591	34,101
May	48,113	10,280	2,077	15,356
June	28,347	10,431	1,602	11,640
July	46,558	5,528	1,531	16,416
August	51,842	8,941	1,413	15,946
September	51,108	9,113	2,601	16,942
October	—	—	—	—*
November	—	—	—	—*
December	—	—	—	—*
Total	400,142	77,497	32,133	217,370†

* Details not received. † For year 1921.

Australasian Gold Outputs.

	October		November	
	Tons	Value £	Tons	Value £
Associated G.M. (W.A.)	6,176	7,588‖	6,171	8,346‖
Blackwater (N.Z.)	3,262	6.549*	3,401	6,717*
Gold'n Horseshoe (W.A)	10,194	5,376‡	10,284	5,540‡
Grt Boulder Pro. (W.A.)	9,333	32,665‖	9,214	32,249‖
Ivanhoe (W.A.)	15,031	6,030‡	15,341	5,902
Kalgurli (W.A.)	—	—	—	—
Lake View & Star (W.A.)	5,339	13,272‖	7,252	14,014‖
Mount Boppy (N.S.W.)	—	—	—	—
Oroya Links (W.A.)	1,415	7,521†‖	1,592	14,453‖†
South Kalgurli (W.A.)	7,542	13,954‖	7,490	13,668‖
Waihi (N.Z.)	13,560	3,752‡ 19,838§	14,638	4,395‡ 31,311§
,, Grand Junc'n (N.Z.)	5,910	1,494‡ 4,188§	6,320	1,391‡ 4,859§
Yuanmi (W.A.)	—	—	—	—

* Including premium; † Including royalties; ‡ Oz. gold; § Oz. silver; ‖ At par.

Miscellaneous Gold and Silver Outputs.

	October		November	
	Tons	Value £	Tons	Value £
Brit. Plat. & Gold (C'lbia)	—	155*p*	—	130*p*
El Oro (Mexico)	33,250	118,000†	31,500	171,000†
Esperanza (Mexico)	—	1,584*e*	—	415*e*
Frontino & Bolivia (C'lbia)	1,950	8,002*	2,240	7,429
Keeley Silver (Canada)	—	102,000*s*	—	36,000*s*
Mexico El Oro (Mexico)	—	—	13,000	183,700†
Mining Corp. of Canada	8,168	140,814	—	—
Oriental Cons. (Korea)	21,424	92,868†	—	101,940†
Ouro Preto (Brazil)	7,100	2,350‖	7,190	2,224‖
Plym'th Cons. (Calif'rnia	8,500	8,600*	7,900	7,757*
St. John del Rey (Brazil)	—	43,500*	—	45,000*
Santa Gertrudis (Mexico)	29,927	13,161‡	32,022	11,311‡
Tomboy (Colorado)	18,000	78,500†	17,000	76,000†

* At par. † U.S. Dollars. ‡ Profit, gold and silver. ‖ Oz. gold. *p* Oz. platinum and gold. *s* Oz. silver. *e* Profit in dollars.

Pato (Colombia): 13 days to December 8, $8,923 from 65,202 cu. yd.

Nechi (Colombia): 17 days to December 15, $45,898 from 123,298 cu. yd.

Indian Gold Outputs.

	October		November	
	Tons Treated	Fine Ounces	Tons Treated	Fine Ounces
Balaghat	3,300	2,371	3,200	2,371
Champion Reef	11,766	4,869	11,616	4,934
Mysore	17,512	10,504	17,569	10,506
North Anantapur	500	602	550	644
Nundydroog	9,011	5,344	8,813	5,362
Ooregum	12,900	8,496	12,900	8,475

Production of Gold in India.

	1917	1918	1919	1920	1921
	Oz.	Oz.	Oz.	Oz.	Oz.
January	44,718	41,420	38,184	39,073	34,028
February	42,566	40,787	36,384	38,872	32,529
March	44,617	41,719	38,317	38,760	32,576
April	43,726	41,504	38,248	37,307	32,363
May	42,901	40,889	38,608	38,191	32,656
June	42,924	41,264	38,359	37,864	32,207
July	42,273	40,229	38,549	37,129	32,278
August	42,591	40,496	37,850	37,375	32,498
September	43,207	40,088	36,813	35,497	32,642
October	43,041	39,472	37,138	35,023	32,186
November	42,915	36,984	39,628	34,522	32,293
December	44,883	40,149	42,643	34,919	—
Total	520,362	485,236	461,171	444,532	358,266

Base Metal Outputs.

		October	Nov.
Broken Hill Prop.	Tons lead conc.	1,312	1,117
	Tons zinc conc.	5,798	4,322
Broken Hill South	Tons lead conc.	3,627	3,588
Burma Corporation	Tons refined lead	3,198	2,922
	Oz. refined silver	401,300	354,850
Mount Lyell	Tons copper	610	534
	Oz. silver	17,519	15,345
	Oz. gold	382	386
North Broken Hill	Tons lead conc.	1,240	1,240
	Tons zinc conc.	1,340	1,340
Pilbara	Tons copper ore	58	100
Rhodesia Broken Hill	Tons lead	1,320	1,169
Sulphide Corporation	Tons lead conc.	1,846	1,828
	Tons zinc conc	3,085	3,281
Tanganyika	Tons copper	2,807	2,714
Zinc Corporation	Tons zinc conc.	9,090	9,735
	Tons lead conc.	791	842

Imports of Ores, Metals, etc., into United Kingdom.

		October	November
Iron Ore	Tons	140,508	176,988
Manganese Ore	Tons	3,164	6,174
Iron and Steel	Tons	172,769	169,237
Copper and Iron Pyrites	Tons	21,030	34,464
Copper Ore, Matte, and Prec.	Tons	3,257	1,359
Copper Metal	Tons	6,869	4,067
Tin Concentrate	Tons	1,524	2,134
Tin Metal	Tons	3.735	1,812
Lead, Pig and Sheet	Tons	6,225	8,852
Zinc (Spelter)	Tons	11,078	8,241
Quicksilver	Lb.	10,202	—
Zinc Oxide	Tons	358	461
White Lead	Cwt.	6,369	6,394
Barytes, ground	Cwt.	34,228	29,614
Phosphate	Tons	29,256	27,421
Mica	Tons	91	92
Sulphur	Tons	497	—
Nitrate of Soda	Cwt.	148,138	222,008
Petroleum: Crude	Gallons	15,432,616	5,156,295
Lamp Oil	Gallons	8,558,514	13,520,894
Motor Spirit	Gallons	21,049,631	17,036,547
Lubricating Oil	Gallons	5,351,509	6,094,872
Gas Oil	Gallons	5,269,963	6,233,798
Fuel Oil	Gallons	54,176,363	34,709,623
Paraffin Wax	Cwt.	62,269	108,870
Turpentine	Cwt.	58,886	17,722

Outputs of Tin Mining Companies.

In Tons of Concentrate.

	Sept.	Oct.	Nov.
Nigeria :	Tons	Tons	Tons
Associated Nigerian	—	—	—
Bisichi	40	45	45
Bongwelli	—	—	—
Champion (Nigeria)	—	—	—
Dua	—	—	—
Ex-Lands	30	30	30
Filani	6¼	6½	3
Gold Coast Consolidated	3	2	2
Gurum River	12	11	12
Jantar	—	—	—
Jos	6½	8	8
Kaduna	17¼	19	21¼
Kaduna Prospectors	12¼	13¼	16¾
Kano	—	—	—
Keffi Consolidated	21	20	25
Lower Bisichi	5¼	3½	4½
Lucky Chance	—	—	—
Minna	—	—	—
Mongu	47½	66	59
Naraguta	50	50	55
Naraguta Extended	25	25	20
Nigerian Consolidated	7½	6¾	9
N.N. Bauchi	83½	55	60
Offin River	—	—	—
Rayfield	24	20	50
Ropp	165	133	135
Rukuba	5	4	3
South Bukeru	13	11	11
Sybu	—	—	—
Tin Fields	14	15	—
Yarde Kerri	7	7	7
Federated Malay States :			
Chenderiang	75*	—	—
Gopeng	89	92	89
Idris Hydraulic	20¾	19½	21½
Ipoh	18	25¼	15½
Kamunting	74*	—	—
Kinta	35¼	41¾	39
Lahat	47¼	53½	48¾
Malayan Tin	77½	77½	89
Pahang	226	211	214
Rambutan	15½	18	19½
Sungei Besi	46	48	54
Tekka	39	39	38
Tekka-Taiping	30	23	24
Tronoh	17	15	30
Other Countries :			
Aramayo Mines (Bolivia)	200	220	264
Berenguela (Bolivia)	32	29	41
Briseis (Tasmania)	13	20	20
Deebook Ronpibon (Siam)	30	30	21
Leeuwpoort (Transvaal)	93*	—	—
Macreedy (Swaziland)	—	—	—
Renong (Siam)	96¾	84¼	115
Rooiberg Minerals (Transvaal)	50	—	—
Siamese Tin (Siam)	102¼	119	166
Tongkah Harbour (Siam)	84	60	60
Zaaiplaats (Transvaal)	—	—	—

* Three months.

Nigerian Tin Production.

In long tons of concentrate of unspecified content.

Note.—These figures are taken from the monthly returns made by individual companies reporting in London, and probably represent 85% of the actual outputs.

	1916	1917	1918	1919	1920	1921
	Tons	Tons	Tons	Tons	Tons	Tons
January	531	667	678	613	547	438
February	528	646	668	623	477	370
March	547	655	707	606	505	445
April	486	555	584	546	467	394
May	536	509	525	483	383	337
June	510	473	492	484	435	423
July	[illegible]	479	545	481	484	494
August	[illegible]	551	571	616	447	477
September	535	[illegible]	526	561	528	595
October	[illegible]	578	491	625	626	546
November	[illegible]	621	472	536	544	564
December	[illegible]	655	518	511	577	—
Total	[illegible]	6,927	6,771	6,685	[illegible]	[illegible]

Production of Tin in Federated Malay States.

Estimated at 70% of Concentrate shipped to Smelters

Long Tons.

	1917	1918	1919	1920	1921
	Tons	Tons	Tons	Tons	Tons
January	3,558	3,020	3,765	4,265	3,298
February	2,755	3,197	2,734	3,014	3,111
March	3,286	2,609	2,819	2,770	2,190
April	3,251	3,308	2,858	2,606	2,692
May	3,413	3,332	3,407	2,741	2,884
June	3,489	3,070	2,877	2,940	2,734
July	3,253	3,373	3,756	2,824	2,734
August	3,413	3,259	2,956	2,786	3,051
September	3,154	3,157	3,161	2,734	2,338
October	3,436	2,870	3,221	2,837	3,161
November	3,300	3,132	2,972	2,573	2,800
December	3,525	3,022	2,409	2,838	—
	39,833	37,370	36,935	34,928	31,011

Stocks of Tin.

Reported by A. Strauss & Co. Long Tons.

	Oct. 31	Nov. 30	Dec. 31
Straits and Australian Spot	2,168	2,112	2,019
Ditto, Landing and in Transit	966	483	635
Other Standard, Spot and Landing	5,194	5,948	5,196
Straits, Afloat	1,655	1,960	1,575
Australian, Afloat	175	70	70
Banca, in Holland	3,916	4,369	5,143
Ditto, Afloat	1,250	266	560
Billiton, Spot	126	121	121
Billiton, Afloat	63	31	—
Straits, Spot in Holland and Hamburg	—	—	—
Ditto, Afloat to Continent	840	900	425
Total Afloat for United States	4,497	4,671	6,833
Stock in America	2,041	1,316	1,696
Total	22,891	22,247	24,273

Shipments, Imports, Supply, and Consumption of Tin.

Reported by A. Strauss & Co. Long tons.

	Oct.	Nov.	Dec.
Shipments from :			
Straits to U.K.	1,675	1,395	1,825
Straits to America	2,075	1,985	3,700
Straits to Continent	775	685	395
Straits to other places	475	250	50
Australia to U.K.	50	150	220
U.K. to America	210	800	2,150
Imports of Bolivian Tin into Europe	1,275	977	1,032
Supply :			
Straits	4,525	4,665	5,920
Australian	50	150	250
Billiton	63	31	—
Banca	1,975	1,233	1,605
Standard	290	559	1,086
Total	6,903	6,038	8,861
Consumption :			
U.K. Deliveries	1,808	2,330	1,766
Dutch ,,	255	427	241
American ,,	2,280	3 250	3,710
Straits, Banca & Billiton, Continental Ports, etc.	446	675	1,170
Total	4,879	6,682	6,887

Outputs Reported by Oil-producing Companies.

		Sept.	Oct.	Nov.
Anglo-Egyptian	Tons..	13,451	12,865	13,959
Anglo-United	Barrels	9,500	10,500	9,500
Apex Trinidad	Barrels	48,305	9,100	—
British Burmah	Barrels	74,940	76,412	71,059
Caltex	Tons..	12,630	13,032	12,761
Dacia Romana	Tons..	278	259	—
Kern River	Barrels	97,118	106,790	117,125
Lobitos	Tons..	8,631	8,911	8,716
Roumanian Consol	Tons..	2,276	2,222	1,800
Santa Maria	Tons..	—	1,357	1,571
Steaua Romana	Tons..	19,485	19,331	17,600
Trinidad Leaseholds	Tons..	10,950	11,900	18,000
United of Trinidad	Tons..	5,700	6,215	4,889

Quotations of Oil Companies' Shares.

Denomination of Shares £1 unless otherwise noted.

	Dec. 6, 1921			Jan. 5, 1922		
	£	s.	d.	£	s.	d.
Anglo-American	5	5	0	4	2	6
Anglo-Egyptian B	1	10	0	1	8	9
Anglo-Persian 1st Pref.	1	3	0	1	3	0
Apex Trinidad	2	0	0	1	17	6
British Borneo (10s.)		11	3		8	9
British Burmah (8s.)		16	3		16	3
Burmah Oil	5	15	0	5	17	6
Caltex ($1)		3	0		3	0
Dacia Romano		15	0		13	9
Kern River, Cal. (10s.)		19	6		18	6
Lobitos, Peru	4	10	0	4	5	0
Mexican Eagle, Ord. ($5)	4	1	3	3	11	3
,, ,, Pref. ($5)	3	18	9	3	8	9
North Caucasian (10s.)		12	6		15	0
Phœnix, Roumania		6	6		11	0
Roumanian Consolidated		8	0		9	6
Royal Dutch (100 gulden)	36	0	0	36	0	0
Scottish American		2	0		2	6
Shell Transport, Ord.	4	15	3	4	12	6
,, ,, Pref. (£10)	8	5	0	8	7	6
Trinidad Central	3	7	6	3	8	9
Trinidad Leaseholds	1	16	3	1	10	0
United British of Trinidad		15	0		13	9
Ural Caspian		11	3		15	0
Uroz Oilfields (10s.)		7	0		6	6

Petroleum Products Prices. January 5.

Refined Petroleum: Water white, 1s. 2d. per gallon; standard white, 1s. 1d. per gallon; in barrels 3d. per gallon extra.

Motor Spirit: In bulk: Aviation spirit, 2s. 6d. per gallon; No. 1, 2s. 2d. per gallon; No. 2, 2s. per gallon.

Fuel Oil: Furnace fuel oil, £4 per ton; Diesel oil, £5 10s. per ton.

American Oils: Best Pennsylvania crude at wells, $3·50 per barrel. Refined standard white for export in bulk, 8 cents per U.S. gallon; in barrels 15 cents. Refined water white for export in bulk, 9 cents per U.S. gallon; in barrels 16 cents.

Dividends Declared by Mining Companies.

During month ended January 10.

Company	Par Value of Shares	Amount of Dividend
Anglo-American Oil	£1	1s. tax paid.
Anglo-Persian Oil	Ord.	20%
Apex Mines	£1	5%
British Burmah Petroleum	8s.	6d. tax paid.
Gopeng Consolidated	£1	9d. less tax.
Great Boulder Perseverance	£1	3d.*
Ivanhoe Gold	£5	1s. 6d. less tax.
Lobitos Oilfields	£1	10% tax paid.
Mexican Eagle Oil	Pref. $10	19%
	Ord. $10	19%
New Era Consolidated	5s.	10%
Ouro Preto Gold	Pref.	5% less tax.
	Ord.	5% less tax.
Rand Selection Corporation	£1	2s. 6d.
Rezende Mines	£1	20%
		25% bonus.
Shamva Mines	£1	7½% less tax.
South African Coal Estates	£1	1s.
South African Townships, Mining, and Finance Corporation	10s.	10%
South Kalgurli	£1	9d. less tax.
Zinc Corporation	Pref. £1	2s.

* Sixth instalment on liquidation.

PRICES OF CHEMICALS. January 7.

These quotations are not absolute; they vary according to quantities required and contracts running.

		£	s.	d.
Acetic Acid, 40%	per cwt.	1	0	0
,, 80%	,,	2	0	0
,, Glacial	per ton	55	0	0
Alum	,,	16	0	0
Alumina, Sulphate	,,	14	10	0
Ammonia, Anhydrous	per lb.		2	2
,, 0·880 solution	per ton	28	0	0
,, Carbonate	per lb.			4
,, Chloride, grey	per ton	37	0	0
,, ,, pure	per cwt.	3	5	0
,, Nitrate	per ton	40	0	0
,, Phosphate	,,	80	0	0
,, Sulphate	,,	14	10	0
Antimony, Tartar Emetic	per lb.		1	6
,, Sulphide, Golden			1	3
Arsenic, White	per ton	40	0	0
Barium Carbonate	,,	8	0	0
,, Chlorate	per lb.			7
,, Chloride	per ton	15	0	0
,, Sulphate	,,	8	0	0
Benzol, 90%	per gal.		3	0
Bisulphate of Carbon	per ton	56	0	0
Bleaching Powder, 35% Cl.	,,	14	0	0
,, Liquor, 7%	,,	5	0	0
Borax	,,	31	0	0
Boric Acid Crystals	,,	65	0	0
Calcium Chloride	,,	8	0	0
Carbolic Acid, crude 60%	per gal.		1	7
,, ,, crystallized, 40°	per lb.			5
China Clay (at Runcorn)	per ton	4	10	0
Citric Acid	per lb.		2	5
Copper, Sulphate	per ton	29	0	0
Cyanide of Sodium, 100%	per lb.			11
Hydrofluoric Acid	,,			7½
Iodine	per oz.		1	0
Iron, Nitrate	per ton	8	0	0
,, Sulphate	,,	3	0	0
Lead, Acetate, white	,,	45	0	0
,, Nitrate	,,	46	0	0
,, Oxide, Litharge	,,	37	0	0
,, White	,,	44	0	0
Lime, Acetate, brown	,,	7	0	0
,, ,, grey 80%	,,	10	0	0
Magnesite, Calcined	,,	21	0	0
Magnesium, Chloride	,,	11	0	0
,, Sulphate	,,	8	0	0
Methylated Spirit 64° Industrial	per gal.		4	0
Nitric Acid, 80° Tw.	per ton	28	0	0
Oxalic Acid	per lb.			9
Phosphoric Acid	per ton	36	0	0
Potassium Bichromate	per lb.			8
,, Carbonate	per ton	23	0	0
,, Chlorate	per lb.			6
,, Chloride 80%	per ton	12	0	0
,, Hydrate (Caustic) 90%	,,	33	0	0
,, Nitrate	,,	45	0	0
,, Permanganate	per lb.			11
,, Prussiate, Yellow	,,		1	3
,, ,, Red	,,		2	3
,, Sulphate, 90%	per ton	15	0	0
Sodium Metal	per lb.		1	4
,, Acetate	per ton	25	0	0
,, Arsenate 45%	,,	42	0	0
,, Bicarbonate	,,	12	0	0
,, Bichromate	per lb.			7
,, Carbonate (Soda Ash)	per ton	15	0	0
,, ,, (Crystals)	,,	7	0	0
,, Chlorate	per lb.			4
,, Hydrate, 76%	per ton	26	10	0
,, Hyposulphite	,,	12	0	0
,, Nitrate, 96%	,,	15	0	0
,, Phosphate	,,	19	0	0
,, Prussiate	per lb.			8
,, Silicate	per ton	11	15	0
,, Sulphate (Salt-cake)	,,	4	0	0
,, ,, (Glauber's Salts)	,,	5	0	0
,, Sulphide	,,	22	0	0
,, Sulphite	,,	12	10	0
Sulphur, Roll	,,	13	0	0
,, Flowers	,,	13	0	0
Sulphuric Acid, Fuming, 65%	,,	24	0	0
,, ,, free from Arsenic, 144°	,,	6	5	0
Superphosphate of Lime, 35%	,,	4	10	0
Tartaric Acid	per lb.		1	5
Turpentine	per cwt.	3	9	6
Tin Crystals	per lb.		1	5
Titanous Chloride	,,		1	0
Zinc Chloride	per ton	22	10	0
Zinc Oxide	,,	41	0	0
Zinc Sulphate	,,	17	0	0

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD, SILVER, DIAMONDS :	Jan. 7, 1921	Jan. 5, 1922
RAND.	£ s. d.	£ s. d.
Brakpan	3 0 0	2 6 3
Central Mining (£8)	7 0 0	5 15 0
City & Suburban (£4)	6 6	2 9
City Deep	2 7 6	2 2 6
Consolidated Gold Fields	18 9	15 0
Consolidated Langlaagte	15 0	12 6
Consolidated Main Reef	13 6	8 6
Consolidated Mines Selection (10s.)	18 6	11 9
Crown Mines (10s.)	2 7 6	1 15 0
Daggafontein	8 6	2 3
Durban Roodepoort Deep	3 9	3 9
East Rand Proprietary	6 6	4 0
Ferreira Deep	8 9	7 6
Geduld	2 8 9	2 5 9
Geldenhuis Deep	8 3	4 6
Government Gold Mining Areas	4 5 0	4 2 6
Johannesburg Consolidated	1 4 6	1 1 2
Kleinfontein	7 6	5 0
Knight Central	5 6	4 3
Langlaagte Estate	13 6	11 9
Luipaards Vlei	2 6	3 0
Meyer & Charlton	4 12 6	3 15 0
Modderfontein, New (10s.)	3 12 6	3 10 0
Modderfontein B (5s.)	1 10 0	1 7 6
Modderfontein Deep (5s.)	2 3 9	2 2 6
Modderfontein East	1 0 0	6 9
New State Areas	1 5 0	1 1 3
Nourse	9 0	7 9
Rand Mines (5s.)	2 11 3	2 1 3
Rand Selection Corporation	3 0 0	2 17 6
Randfontein Central	11 0	10 6
Robinson (£5)	9 0	9 0
Robinson Deep A (1s.)	11 3	7 6
Rose Deep	16 9	12 6
Simmer & Jack	3 0	2 6
Springs	1 16 3	1 15 0
Sub-Nigel	13 9	10 0
Union Corporation (12s. 6d.)	16 6	14 6
Van Ryn	12 6	11 0
Van Ryn Deep	3 17 6	3 7 6
Village Deep	8 9	7 6
West Springs	16 3	7 6
Witwatersrand (Knight's)	13 9	13 9
Witwatersrand Deep	7 0	7 3
Wolhuter	3 9	3 0
OTHER TRANSVAAL GOLD MINES :		
Glynn's Lydenburg	10 0	8 0
Transvaal Gold Mining Estates	8 6	7 3
DIAMONDS IN SOUTH AFRICA :		
De Beers Deferred (£2 10s.)	13 5 0	9 10 0
Jagersfontein	3 0 0	2 2 6
Premier Deferred (2s. 6d.)	5 15 0	4 10 0
RHODESIA :		
Cam & Motor	8 0	8 6
Chartered British South Africa	15 0	11 6
Falcon	10 6	4 6
Gaika	11 0	9 0
Globe & Phœnix (5s.)	12 6	11 6
Lonely Reef	2 10 0	2 2 6
Rezende	2 15 0	3 5 0
Shamva	1 11 3	1 8 9
WEST AFRICA :		
Abbontiakoon (10s.)	2 9	2 6
Abosso	9 0	6 6
Ashanti (4s.)	15 3	13 6
Prestea Block A	2 0	1 3
Taquah	10 0	8 6
WEST AUSTRALIA :		
Associated Gold Mines	3 0	3 3
Associated Northern Blocks	3 9	2 0
Bullfinch (5s.)	1 0	1 0
Golden Horse-Shoe (£5)	15 0	10 0
Great Boulder Proprietary (2s.)	5 3	5 6
Great Fingall (10s.)	1 6	1 6
Hampton Celebration	5 0	2 9
Hannan's Properties	7 6	4 3
Ivanhoe (£5)	18 9	18 9
Kalgurli	11 3	19 0
Lake View Investment (10s.)	11 3	8 3
Lake View and Star (4s.)	2 6	1 9
Oroya Links (5s.)	1 6	1 3
Sons of Gwalia	5 0	3 3
South Kalgurli (10s.)	6 0	7 6

GOLD, SILVER, *cont.*	Jan. 7, 1921	Jan. 5, 1922
NEW ZEALAND :	£ s. d.	£ s. d.
Blackwater	8 9	2 6
Waihi	1 6 3	18 9
Waihi Grand Junction	8 9	7 6
AMERICA :		
Buena Tierra, Mexico	6 3	1 9
Camp Bird, Colorado	7 6	3 3
El Oro, Mexico	11 6	8 0
Esperanza, Mexico	1 6 3	16 6
Frontino & Bolivia, Colombia	8 0	5 0
Kirkland Lake, Ontario	5 0	9 0
Le Roi No. 2 (£5), British Columbia	5 0	2 6
Mexico Mines of El Oro, Mexico	5 10 0	3 10 0
Nechi (Pref. 10s.), Colombia	7 6	5 0
Oroville Dredging, Colombia	1 2 6	1 3 9
Plymouth Consolidated, California	17 6	3 9
St. John del Rey, Brazil	13 6	16 0
Santa Gertrudis, Mexico	12 6	5 0
Tomboy, Colorado	7 6	6 3
RUSSIA :		
Lena Goldfields	12 6	8 9
Orsk Priority	5 0	5 0
INDIA :		
Balaghat (10s.)	7 6	6 3
Champion Reef (2s. 6d.)	2 9	1 6
Mysore (10s.)	12 6	11 3
North Anantapur	2 6	2 6
Nundydroog (10s.)	4 9	8 0
Ooregum (10s.)	11 3	11 6
COPPER :		
Arizona Copper (5s.), Arizona	1 10 0	16 3
Cape Copper (£2), Cape and India	15 0	7 6
Esperanza, Spain	5 0	4 6
Hampden Cloncurry, Queensland	5 0	5 0
Mason & Barry, Portugal	1 10 0	2 15 0
Messina (5s.), Transvaal	4 0	3 0
Mount Elliott (£5), Queensland	10 0	1 2 6
Mount Lyell, Tasmania	16 3	16 0
Mount Morgan, Queensland	12 6	12 0
Namaqua (£2), Cape Province	1 5 0	17 6
Rio Tinto (£5), Spain	25 0 0	28 0 0
Russo-Asiatic Consd., Russia	9 3	11 0
Sissert, Russia	11 3	5 0
Spassky, Russia	12 6	12 6
Tanganyika, Congo and Rhodesia	1 6 3	18 9
LEAD-ZINC :		
BROKEN HILL :		
Amalgamated Zinc	17 6	15 0
British Broken Hill	1 1 3	1 3 9
Broken Hill Proprietary	2 3 9	1 5 0
Broken Hill Block 10 (£10)	15 0	7 6
Broken Hill North	1 10 0	1 11 3
Broken Hill South	1 12 6	1 7 6
Sulphide Corporation (15s.)	12 6	9 3
Zinc Corporation (10s.)	12 6	10 6
ASIA :		
Burma Corporation (10 rupees)	8 6	6 0
Russian Mining	7 6	5 9
RHODESIA :		
Rhodesia Broken Hill (5s.)	8 3	5 6
TIN :		
Aramayo Mines, Bolivia	2 15 0	1 18 9
Bisichi (10s.), Nigeria	6 3	6 9
Briseis, Tasmania	4 0	3 3
Chenderiang, Malay	15 0	11 3
Dolcoath, Cornwall	6	6
East Pool (5s.), Cornwall	7 0	3 0
Ex-Lands Nigeria (2s.), Nigeria	2 3	1 6
Geevor (10s.), Cornwall	3 9	2 6
Gopeng, Malay	1 10 0	2 0 0
Ipoh Dredging, Malay	13 9	10 0
Kamunting, Malay	2 10 0	18 9
Kinta, Malay	1 12 6	1 18 9
Lahat, Malay	2 10 0	10 0
Malayan Tin Dredging, Malay	1 8 9	1 6 3
Mongu (10s.), Nigeria	13 9	12 6
Naraguta, Nigeria	10 0	13 9
N. N. Bauchi, Nigeria (10s.)	1 9	2 6
Pahang Consolidated (5s.), Malay	7 3	6 3
Rayfield, Nigeria	4 0	3 6
Renong Dredging Siam	1 13 9	1 7 6
Ropp (4s.), Nigeria	7 0	6 0
Siamese Tin, Siam	2 10 0	2 0 9
South Crofty (5s.) Cornwall	7 9	4 9
Tehidy Minerals Cornwall	10 0	6 3
Tekka, Malay	1 0 0	18 9
Tekka-Taiping, Malay	1 3 9	1 1 3
Tronoh, Malay	1 6 3	1 6 3

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

In this section we give abstracts of important articles and papers appearing in technical journals and proceedings of societies, together with brief records of other articles and papers; also notices of new books and pamphlets, lists of patents on mining and metallurgical subjects, and abstracts of the yearly reports of mining companies.

MINING WIDE PYRITIC ORE-BODIES

At the meeting of the Institution of Mining and Metallurgy held on December 15, A. V. Reis, of the Tharsis mine, read a paper on underground methods of mining wide pyritic ore-bodies, with particular reference to the mining of pyrites in the south of Spain.

The masses of pyrites in the south of Spain are found either totally enclosed in clay slate, on the contact of slate and an igneous rock, or completely enclosed in the igneous rock. The lodes of most importance are to be classed under the heading of contact masses. They are approximately vertical, more or less lenticular in form, following the general strike of the country rock, and have a length of from a hundred metres to over 1,000 metres, with widths of from a few feet to from 60 metres to 80 metres; in one instance a well-known mass has a width at one section of nearly 200 metres. Such masses require special study in order to evolve a system of working for maximum recovery of the ore, with due regard to safety and economy. The ore varies in character from a very friable, spongy, and granular material to one which is very hard, compact, and close-grained. There are many grades in hardness, and within the same mass zones are sometimes found in which these extremes are noted. The ore-bodies are usually very homogeneous in chemical composition, and in the case of the hard ores, are likewise so in the physical sense. The soft ores are generally much jointed, probably due to earth movements posterior to formation. Jointing or extensive breaks in the general homogeneity of an ore-body must be kept in view in the consideration of a system of working, since the presence of an important slip or joint may seriously endanger the safety of a pillar or bring about a fall of ore in stoping. In a broad sense jointing is of less importance in the softer ore-bodies than in the harder types.

The property which iron pyrites has of firing spontaneously is one which seriously restricts the application of known methods of mining to the extraction of these masses. The hard, compact and close-grained ores on being broken down in stoping are much less liable to this chemical action than the more friable ones, but the latter grade of mineral, in which the danger of ignition is of such paramount importance, must be mined with the greatest caution, as regards movement or crush. The menace of spontaneous combustion must always be kept in mind as a very real one, and in the selection of a system of mining may even become the determining consideration in the choosing of a suitable method.

The system of open pillar-and-stall, without filling, was at one time the method of mining these enormous masses, and was continued to very considerable depths. It was, however, abandoned some twenty years ago, due to the difficulties inherent in such a system, and the great loss of ore involved. The method has nothing to commend it, and in several of the ore-bodies, where its application was persisted in, conditions now prevail that prevent the adoption of any general and successful method of mining at this time. The recovery of the pillars in such immense lodes to considerable depth, coupled with the danger of ignition on movement or crush, led to the introduction of a system of complete replacement by filling.

Stoping in Transverse Sections.—The next method to be adopted was that of stoping in transverse sections. This system consists in splitting up the lode on any given floor into a number of main transverse stopes, set off at convenient points to suit the local conditions at distances apart varying from 40 m. to 100 m. The main stopes are 15 m. wide, and are opened out on several floors in the same vertical plane consecutively, the upper floor excavations leading. On the completion of the operations in the main stope, "ampliaciones" or side-cuts are opened on the right and left of the main stope and are carried 10 m. wide, the length of each being the full width of the lode at that section. The stoping is at all times accompanied by complete filling of the excavations with waste rock as soon as the ore is extracted. The actual working face carried forward at one time is very limited in area, and the possible output from any given section of the mine is therefore small. The enormous number of open spaces left by the earlier system of mining were filled with waste rock previous to commencing mining operations, openings being left in the filling to attack the pillars conveniently. Roads are built up in the waste filling longitudinally, the general practice being to have a road at every 20 m. across the mass. On account of the width of the mass two or three such roads were generally required, and even more in other cases where the width became greater. The roads are arched, constructed of stone, selected from the waste rock, built in with mortar. No timber of any kind is used within the stoping area for permanent work. Opening up was commenced at a number of levels within the same vertical stope or column, starting at the top, the upper levels always leading. This work consisted in cutting out the pillars to the height of 4 m., the original height of the stalls, and filling in the excavation; forming in the waste the roads, ore-passes, manways, and any other works required for the succeeding mining operations. The extraction of the pillars was generally carried out retreating from the two walls towards the centre. The ore-passes and manways of circular section, each 1 m. diam., were built up of stone and mortar in the waste, at the sides of the stopes, and placed in pairs over each longitudinal drift. In opening up a horizontal slice of 2 m. in height, the cross-cuts between the manways are first driven ; thereafter narrow places are opened up successively, each being filled in immediately. The succeeding slices, each of 2 m. height, are taken out in a similar manner. The floors are 12·5 m. apart, and the stages are : (1) Cutting out the pillars to 4 m. height ; (2) three horizontal slices each of 2 m. height ; (3) the cutting out of the chain pillar. At first the chain pillar of 2 m. thick was left in for the protection of the longitudinal roads and overhead drifts ; but these thin decks proved insufficiently strong for the purpose, and later experience led to the decision to cut them out also. In many cases repair work was necessary to maintain the drifts for the secondary workings or "ampliaciones" on either side of the main transverse stope. The ore from the stopes is discharged through the ore-passes to the chute placed in the longitudinal galleries, where it is drawn off at the lower level corresponding to the working, and the waste filling was run in by wagons from shafts in the wall on the north side, and dropped through small shafts sunk in the ore at sites over the ore-passes in the stopes. The "ampliaciones" or secondary stopes are mined out in a similar fashion on a width of 10 m. instead of 15 m.

The disadvantages of this system are: (1) Enormous extent of drifts to be maintained ; (2) comparatively small output of each working place ; (3) scattered area for gathering ore and for distributing waste rock ; (4) difficulty of adequate ventilation ; (5) subsidence of the longitudinal and other drifts, and difficulty of their maintenance. All these disadvantages necessarily spell comparatively high working costs, which are in actual practice found to characterize the output from the masses worked by this system. There is always the danger of complete subsidence of any individual stope, due to the weight of the overhead ground coupled with the weakness of the ore to support it and resist movement. Such a condition is ever a menace to the security of the upper workings, and might lead to the simultaneous collapse of a considerable number of floors, within the same transverse section of the ore-body.

Stoping in Longitudinal Sections.—The author then proceeds to describe the method of stoping in longitudinal sections with central cut, by giving details of a specific case (Fig. 1). In the development of the mass, cross-cuts had been driven at distances of approximately 70 m., and these transverse drifts were utilized in opening up the central stope. The first horizontal slice of 2·5 m. in height was commenced from the cross-cuts by means of driving a central gallery throughout the entire length of the stope, from which cross-cut places were driven 4 m. wide from the gallery to either side, being stopped at the limit of the width of 20 m. to be taken. In the primary working, these places were driven staggered, leaving pillars of 8 m. As soon as a 4 m. place reached its limit of working, waste rock was run in and a dry stone wall some 3 ft. thick was built up vertically against the solid ore remaining, the remainder of the space being completely filled in with waste rock. The pillars were thereafter cut out and the spaces filled. This careful method of cutting out places was abandoned, as experience demonstrated the practically homogeneous nature of the ore-body, and breast-stoping was then carried out from limit to limit, that is, on a breast of 20 m. When the ore on either side of the central road had been mined out and the excavation filled in, a permanent road was maintained with round timbers of 5 in. to 7 in. diameter, lagged at the sides and top and completely packed outside with waste rock. Spaces of 3 m. by 3 m. for rises are timbered at distances of some 30 m. at one side of the timbered road for the purpose of breaking up overhead to open out the next horizontal slice. These places were started as soon as the timbered gallery on the working slice, with both sides completely built in, had been advanced some 7 m. to 8 m. on either side longitudinally. The drift on the upper slice was carried alongside the timbered road buildings of the lower slice, the ore from the drivage being tipped into wagons from short chutes set in between the timbers of the road. As soon as the mining out of the lower slice had progressed sufficiently, the stoping on either side of the gallery on the upper slice was commenced, the timbers of the road on the lower slice were withdrawn, and the road filled in, utilizing such timbers in the successive slices. In the actual working of the stope, two slices were always in operation and at certain stages three. Waste for filling was loaded into small side-tipping wagons of 0·15 cu. m. capacity at an old tip heap on the surface, lowered by means of balanced cages, controlled by brake, in special rock-shafts in the wall of the lode placed at the ends of the stoping area, the shafts serving also as return airways for the ventilation of the section.

In the upper of the two levels mined by this method, the stoping was carried right up to the capping overhead. In the lower the operations were suspended at a vertical distance of 5 m. below the level of the upper floor. This, therefore, formed a chain pillar of 5 m. thick for the protection of the secondary working galleries. The upper workings were maintained well in advance of the lower ones, which were vertically below them. The side "ampliaciones" or cutting out of the section of ore left on the wings were commenced on the upper level with the closing of operations on the central stope of the lower level.

The longitudinal "ampliaciones," or lateral stopes, were laid out to be advanced longitudinally on a width of 10 m. ; it was, however, feared that this might be too great an overhang, as indeed was proved later by experience. The first horizontal slice on the floor level was opened out from the cross-cuts to a height of 2½ m. over the whole intended width of 10 m. and filled in successfully, without any movement of the overhanging ore-body. Spaces in the cross-cuts were left for the placing of the ore-passes and manways. The second horizontal slice was then commenced, the system of working being that of breast-stoping, carrying forward the whole width at one cut, filling in as soon as practicable after excavation, and closely building up with stone. The tramming road was very narrow, 1·50 m. between timbers, its centre line being at a distance from the waste filling of the old workings of some 4 m. As a protective measure against any sudden breakaway of the roof, timber cribs, chocks, or pigstyes filled during building with waste rock, were placed by the side of the road way under the overhanging part at intervals of 2 m. ; the timbers were then placed in position, carefully packed to roof and sides, and as close as feasible to the advancing breast. This method was carried on quite successfully until a small fall of ore took place. On investigation it proved to be due to a set of very prominent joints forming a

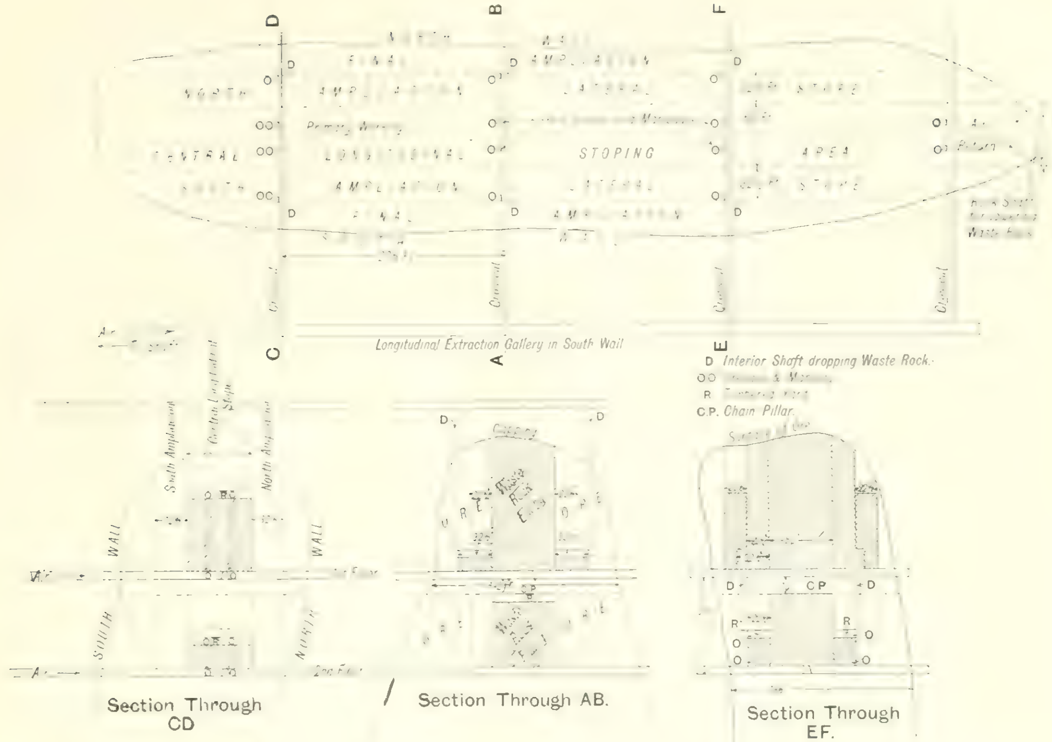


FIG. 1.—CENTRAL LONGITUDINAL SECTION; WITH CROSS-SECTIONS SHOWING THREE STAGES.
D=Interior shaft dropping waste rock. O=Ore-pass and manway. R=Timbered Road. C.P.=Chain Pillar.

prismoid of ore, which, as soon as its support was cut away, subsided on to the timbered cribs and waste filling below. This incident did not in any way influence the general principle of the system, due to the solid nature of the block and the facility for extracting it later. The main lesson learned from this condition was that of warning; careful and systematic sounding of the roof was enforced thereafter, and, during quiet periods, a close watch was kept for any movement. After the experience of these falls it was decided to diminish the width of the longitudinal "ampliaciones" or laterals to widths of 7 m. and 6 m. and to observe the conditions created thereby. Subsequent experience has shown that these widths are quite satisfactory, and the principle of the method has been successfully maintained. In the actual stoping, the ore next the old waste filling or under the overhanging side is first broken down, and the excavation at once filled in. The dry stone wall of the original working stands extremely well, and gives no trouble. The timber cribs are built in at the sides of the road, and the timbered roadway is placed in position, and carefully packed on all sides. At the line of the intended limit of the stope width, a dry stone wall is built as in the previous working right up against, and supported by, the solid ore remaining. The cross-cuts are maintained until the longitudinal "ampliaciones" or laterals are completely extracted, and serve subsequently for the dropping of waste rock to the secondary workings on the level below.

The central longitudinal stoping method just described was successful in so far as it fulfilled all the chief requirements, but it was felt that something more could be done towards increasing the stoping width in the primary working and suppressing altogether in this particular case the lateral cut or "ampliacion" on the south or slate wall. Both these points are of considerable importance. The fact of the ore being frozen to the wall-rock of the north or igneous wall is a condition which permits of facility in working, and of utilizing to the full the natural properties of the ground. Thus there was introduced a method of longitudinal stoping with primary working on one wall. The system as put into working was that of longitudinal stoping with its corresponding lateral cuts or "ampliaciones," but commencing operations from the south wall, instead of in the centre of the mass. The author gives details of this method of working.

Proposed Central-Pillar Method.—The author proceeds to describe a proposed central-pillar method of mining (Fig. 2), as applied to a virgin ore-body of, say, 60 m. in width, varying from a close-grained compact class of ore to one fairly jointed and friable. The length might be some 1,000 m. and the dip approximately vertical. This method brings in a further step in the development of the longitudinal system. It is believed that the system of leaving a large continuous pillar in the centre of the mass, throughout the whole length of the ore-body, will give the most favourable method of mining.

For this system the following advantages are claimed: (1) Maximum primary extraction; (2) safety in working; (3) economical working costs; (4) security against movement and crush, hence against the risk of spontaneous combustion; (5) small cost of development; (6) the simultaneous utilization of the maximum workable area of the mass; (7) centralization and concentration of work, with facility of supervision. A pillar of approximately 10 m. should be left in the line of the longitudinal axis of the ore-body, which in a mass of 65 ft. width represents some 15% of the total tonnage of the ore-body, admitting of a primary extraction of 85%. If the lode has good walls the stoping areas may be made of equal widths, but should one wall be relatively unfavourable the stoping area on the other side of the pillar may be correspondingly increased. That is to say, in a total width of 65 m., supposing 10 m. to be left for a central pillar, the remaining 55 m. may be distributed as desired, say, for example, on the north

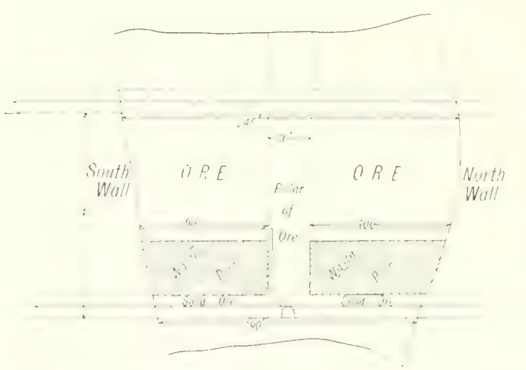


FIG. 2.—LONGITUDINAL SECTION WITH CENTRAL PILLAR.

side 30 m. and on the south side 25 m., these widths having been proved by experience to be amply safe for a single working. Such an arrangement may be prepared for in advance of any opening up of permament works, by simply laying out the pillar farther to the south, a distance, in this instance, of 3 m. from the axis of the mass. In all mining operations in large ore-bodies, the cross-cuts and longitudinal galleries within the stoping areas require continual repair and modification. It is preferable to place such works in the solid, and for this reason all such works will be considered as from this standpoint. A cross-cut of 3 m. by 3 m. is sufficient for a single track road, and the minimum thickness of ore to protect it from the weight of the superincumbent waste rock of the filled stope may be taken as some 3 m. in height from the roof of the cross-cut. The longitudinal road with a single track should be placed on the floor level in the centre of the pillar, and will contain all the chutes for drawing off the ore from the stoping areas to the north and south. There should be at least three permanent cross-cuts connected to the central longitudinal road, besides communications at either end of the mass, all connected with the longitudinal gallery in the south wall. This arrangement of single tracks will admit of the reduction in the width of the road in the longitudinal pillar, utilizing certain roads for the running in of the empty wagons and others for the return of the loaded wagons to the shaft without unduly long hauls. The method of working in the stopes is similar to that employed in the other longitudinal systems, namely, by flat-back stoping with contemporaneous filling. A more economical variation in the method of stoping will be found by employing gravitation as a means of running in the waste rock, thereby saving the shifts generally employed in transporting such filling to the site of excavation. This is carried out by starting to break down the ore advancing from an ore-pass which will have a rock-shaft in the immediate vicinity. The height of the roof instead of being limited to 2½ m. is carried to 5 m. to 7 m., and advanced longitudinally to another set of ore-pass and shaft. At this stage the ore is loaded and trammed to the ore-pass, and the excavation filled in by simply pushing forward the track and tipping the wagons of waste rock loaded from the rock-shaft situated at the entrance to this area. The stoping area may be arranged in stages, one end advancing at the higher horizon; the length of the stage will be regulated by the distance apart of the ore-passes and rock-shafts. The stoping is commenced from the cross-cuts on the floor-level, and the solid ore left where the permanent openings are to be placed. The ore-passes, 30 m. apart, are cut out of the solid pillar as the work ascends; three sides are in ore, the fourth side is built up of timbers, protected by steel plates spiked to the wood, on the limit of the pillar in the waste filling. Manways are built up from the floor level at suitable sites, as inclined roads in the waste filling alongside the pillar. Similarly, manways can be cut out of the solid in the pillar over the position of the ore-passes from the floor level overhead; every alternate one may be utilized for tipping in waste rock for the filling of the stope, and others may be opened where required.

Whether or not a shrinkage system is permissible in pyrites, mining can only be determined by the propensity of the ore to self-ignition. Based on this factor it might be feasible in certain cases to employ a system of shrinkage on the north side, and on the south side one of flat-back stoping with contemporaneous filling. The vertical height of the stope will, however, influence the application of shrinkage, since heights of 30 m. and 45 m. are usual in this class of mining, and in such dimensions it is believed that the employment of shrinkage would require at least to be combined with a method of filling, in order to reduce the height of face in such a working. Shrinkage systems could only be applicable in the case of a few ore-bodies that are composed of specially dense and compact ore, since not only friable ores but those that are slightly porous and granular in their structure become permeable to the oxidizing influences of air and water, so that the danger of ignition would be in most cases altogether too great to be risked.

The ultimate recovery of the longitudinal pillar may be carried out quite economically by splitting it up into transverse pillars of 20 ft. thick, with stoping areas between them of 60 ft. This would be safe, and even considering that the pillars so left might have to be altogether abandoned, the loss of ore would be small, say 25% of the 15% which was left in originally, so that the final loss would represent a total of under 5%. To cave a column of such small dimensions as the longitudinal pillar would not be found in practice to be economical, even granting the feasibility of its application. Drivages in pyrites are generally very costly, and the advances slow in the average grade of ore. The remaining isolated pillars of 7 m. thick by 10 m. long might, however, be partly recovered by caving, since the limits of the ore could well be reached by small drivages, and the pillar shattered in stages descending from the upper level.

THE MINERAL RESOURCES OF UGANDA

We continue herewith our extracts from the first annual report of the Geological Department, Uganda Protectorate, covering the year ended March 31, 1920, and written by E. J. Wayland and W. C. Simmons.

Native Metal Lore.—The only metal now smelted and worked is iron, and though there are records that copper or brass was known to the natives in times past, yet all knowledge of the art of working copper, or of the localities of the copper mines (possibly small deposits of native copper) has now disappeared. In the evolution of man in Europe it has been found that the copper tools were generally the first used after the stone age, and it may be only a coincidence that in the Baganda's legend of the creation of the first Muganda, Kintu is given a copper axe by Magulu. No other reference that might throw any light on their metal craft or the presence of ancient mines or workings of any sort can be found among the legends of the Baganda. In the Katikiro's book on the customs of the Baganda, a good description of the iron smelting and forging customs of the Baganda is given, and it is also stated that the art of copper or brass working is lost, though some of the old ornaments remain (called Eng'ang'a). It appears that the Banyoro were the first among the Bantu people to smelt iron, and it is clear that the Baganda brought iron smelters and smiths from Banyoro to teach them the craft. One paragraph from the work mentioned may be translated as follows: "And King Mawanda engaged a Munyoro whose name was Kakonge and who lived among the rooks (yava mu mainja), and he took him to Kyagwe, and gave him a village called Namumira to be his home while he smelted iron, because in the rocks of Bukunju on the edge of the lake there is much iron ore." Other kings are mentioned as getting other Banyoro, either from Bunyoro proper or from Singo, to smelt iron ores, and their perquisites and privileges are given at length. Even at the present time the Banyoro are the chief iron smelters, and the Baganda smiths prefer to work up old iron or iron purchased from the Banyoro. There always has been an import of Bunyoro hoes into Buganda, and when the cheap European hoes were rendered scarce by the war the Banyoro smiths received a fresh stimulus to work, owing to increased price.

No natives of the Protectorate, so far as known, have any precious metals of local origin, and even the names of gold and silver seem to have been imported with the metals by the Arabic traders. Gold, which is a metal so easily worked and so untarnishable as to be generally prized, even by the most primitive races, was unknown to them, so that it is probable that there were no easily worked deposits discovered. It is probably an effect of the country being so much covered with lateritic drift deposits, that the Bantu people have been backward in metal lore, and have only achieved the making of iron implements of warfare and agriculture and tools for domestic purposes of somewhat primitive types; their chief riches have been in pastoral and agricultural products, or trophies of the chase. They do not seem to have had any jewels, and with the exception of the brass anklets, etc., few ornaments of anything more durable than ivory, wood, animal skins, or woven grass were used. Hence the only names of metals not introduced seem to be ekuma and ekikomo for iron and brass or copper.

Gold.—Gold is widely distributed in Uganda, but it has not yet been proved in paying quantities. In most cases gold recoveries have generally been made from alluvial deposits, but in two instances, at any rate, reef has been located. In one case a prospector found in Bunyoro what he described as quartz reef carrying gold amalgam. Three samples of this were sent to the Imperial Institute about five years ago, and the Director furnished a report, the substance of which was as follows: No. 1 sample consists of quartz with some pyrite and pyrrhotite; No. 2 of quartz with some iron oxide and graphite; No. 3 is a fine-grained siliceous rock consisting of quartz, felspar, with a small amount of pyrrhotite. The assays of the three were as follow:—

	Silver per ton			Gold per ton		
	oz.	dwt.	gr.	oz.	dwt.	gr.
No. 1 . .	0	1	3	0	0	12
No. 2 . .	0	1	4	0	0	10
No. 3 . .	0	0	23	0	0	8

A banket carrying gold was discovered by the Government Geologist this year in the Buganda kingdom. In addition to this a few prospectors have claimed to have discovered reefs in various parts, but no attempt has ever been made to work any of them. As may be imagined, rumour has a good deal to say about the occurrence of gold in Uganda, and naturally enough most of the hearsay stories centre on the West Nile Province. The position of West Nile in relation to the goldfields of the Belgian Congo and the general outlines of its geology suggest that here, if anywhere in Uganda, gold in quantity will be found.

It is probable that most of the gold which has been obtained from alluvial deposits in this country is a residual product set free by the breakdown of pyrite and pyrrhotite. Pyrite and pyrrhotite, particularly the former, are very conspicuous minerals in some of the quartzites of the argillite series. The crystal habit is generally that of the cube, and the crystals themselves show a curious honeycombed surface. When they decompose they give rise to a jet-black goethite, which does not occupy quite the same space as the pyrite did; this is highly characteristic of the pyritiferous quartzites of Uganda. Apart from alluvial gold the possibilities in the present connexion appear to be: (1) Pyritiferous quartzites; (2) banket; (3) quartz reefs; (4) highly acid igneous intrusions; (5) metamorphic rocks of the Archæan complex. The more promising reefs are likely to be those of hydatogenitic origin cutting the Archæan complex, but it is probable that in the event of payable gold being discovered in this country, alluvial, rather than reef, will form the basis of a business proposition.

In the territory that was lately called German East Africa gold has been recovered from quartz veins traversing (1) granite with dioritic intrusions and pegmatites, (2) hornblende-schists, and (3) mica-schists. All these rock-associations exist in Uganda.

TIN.—Cassiterite has been found in Uganda, as have traces of native tin, while the possibility of the association of cassiterite with tourmaline intrusions has also been mentioned. No tin lodes have yet been located, and it is not yet known whether any of the granite rocks carry the mineral or not. A specimen labelled "cassiterite" from Toro, in the collection of the now defunct Scientific Department proved on examination to be zircon.

COPPER.—Roccati records the occurrence of copper ores in the form of chalcopyrite on Mount Baker, and malachite, tetrahedrite, and chalcopyrite on Mount Stanley. Copper ores on the latter peak are, according to him, plentiful. Chalcopyrite has been found in one of the streams that flows down from Ruwenzori. In the more accessible parts of the Protectorate copper has only been met with in traces as yet. If found in quantity it will probably be in connexion with the pre-argillite rocks, and as these are well developed in some parts of the Eastern Province, a discovery of copper in that area would not be surprising. Copper appears as an inconstant constituent of metallic sulphides, such as pyrite and pyrrhotite, in this country, and is left as a "stain" (thin films of oxidized ores) in some gozzans. It is possible that certain gozzans may yield copper in depth ; for it does not follow that copper salts will be left in the residues of the "iron hat," though such will usually be the case.

LEAD AND SILVER.—In the collection of the Scientific Department there were several lumps of galena, which were supposed to have been found in Uganda. There was no label, however, to indicate the locality from which they came. A galena lode is said to be crossed by the Entebbe-Kampala Road, and to crop out in the Botanical Gardens at Entebbe ; but no trace of it has been seen by the officers of the Geological Department. Roccati records the existence of galena in a gangue of calcite on the Wollaston Peak, Ruwenzori. Silver has been found in connexion with pyrite and pyrrhotite. Galena occurs, of course, in British East Africa.

ALUMINIUM.—Bauxite has been found in both the Northern and Eastern Provinces and Buganda, but the isolated position of Uganda renders this ore of little or no value. Specimens of diaspore occasionally find their way to the Geologists' office. They seem to indicate the existence of large quantities of the mineral occurring in beds in the argillites. The occurrence is, at any rate, remarkable and deserving of investigation when the opportunity arrives.

IRON.—Iron ores of various kinds are abundant in Uganda ; those of average grade such as limonite ($2\ Fe_2O_3\ 3H_2O$) are of extremely wide occurrence. Both ferric and ferrous oxides exist in the surface soils of most districts. The protoxide present in many rocks suffers oxidation and hydration, and thereby, owing to an increase in bulk consequent upon the molecular change, loosens the sub-soil and turns it into the common red-earth so characteristic of the country. When, however, the peroxide is again reduced by the action of organic substances in solution a red colour very generally remains. Another hydrous peroxide of iron of common occurrence is goethite ($Fe_2O_3H_2O$). It is usually found in association with certain post-argillite quartz reefs, and generally results from the decomposition of hematite or of pyrites. It is worthy of remark that goethite, which might almost be classed as a rare mineral in Britain, is very common in Uganda. It is worked as an ore of the metal in some countries.

Limonite is frequently concentrated in the surface laterites, and other detrital deposits, giving them the slaggy appearance which causes those unacquainted with the true nature of the rocks to regard them as volcanic. Surface ores such as these are often worked by the natives of this Protectorate.

Apart from these ores, however, others of economic importance are known ; hematite and magnetite are locally abundant. It is a curious fact that the hematite of this country nearly always contains a greater or smaller proportion of magnetite. Martite (probably a pseudomorph in hematite after magnetite) is known to occur, but is not known to be worked ; on the other hand turgite occurs in the Northern and Eastern Provinces, and is worked in both.

Magnetite in more or less shapeless masses is found in some pegmatites, and is extremely common as scattered octahedra in the lavas of the Mount Elgon series, and may be obtained in quantity from some of the alluvials derived therefrom. Apart from an occurrence discovered immediately after the close of the financial year 1919–1920, the best magnetites as yet known are found in certain quartzites associated with the crystalline rocks of the Archæan. It is not yet certain whether these quartzites belong to the ancient complex, whether they rest upon it, or are only faulted against it ; but the probabilities as they stand are generally in favour of the last supposition.

Hematite occurs under precisely similar conditions, and is a good deal more common than magnetite, while hematite-magnetite and magnetite-hematite-limonite ores (often with goethite) occur similarly. Hematiferous argillites are known, more especially in the western parts of the Protectorate, while in the Kigezi district some fine hematite-magnetite schists occur, as do massive hematite-magnetite ores.

The iron-ores of the quartzites are usually irregular and patchy, and while some are to be regarded as bedded deposits, others are of the nature of fissure ores filling in the joints and cracks of the main rock. They are commonly of the nature of magnetite. Hematites, often resembling them in general appearance, are known in quartz-hematite reefs, which cut the argillites in some places.

The abundance of iron ores in Uganda has attracted the notice of most explorers. Emin Pasha says in one place (see *Emin Pasha in Central Africa*, London, 1888, p. 122) : "I must here once more refer to iron, of which a very excellent quality is manufactured in all parts of Uganda and Unyoro, the iron of the former country being softer than that of the latter. It is sometimes obtained from bog iron-ore in low-lying lands, but usually from clay ironstone, resembling roe or kidneys in its formation, and lying upon the granite. In certain places this ironstone proves extraordinarily rich, for instance, on the mountains round Kisuga, in Unyoro. The iron need not fear comparison with good European kinds."

It is difficult to say which district produces the best iron, but Kigezi must take a high place. The blacksmiths of that part are a very exclusive caste. They carry on a considerable trade with the country to the south and west, and also with their immediate neighbours on the east.

The collection of ore for native furnaces is very primitive, and usually takes the form of simple surfacing. In Bunyoro, however, a certain amount of tunnelling is undertaken. On the discovery of likely indications a small shaft is sunk some 20 ft. or so below the surface of the ground and through the superficial deposits until the ore (the weathered cap of a hematite lode or some kind of bedded deposit) is struck. The shaft is continued into this, and short tunnels of small dimensions are driven out in various directions from the bottom of the shaft into the ore, which is thereby dug and subsequently extracted. No timbering is used, but the lateritic earth above the ore stands very well, as does the ore itself. These "mines" are neither extensive nor is this method of winning them frequently resorted to.

The system of melting iron, and sometimes of smelting small quantities of ore, common to a good deal of Central Africa, is described by Sir Harry Johnston thus (see *The Uganda Protectorate*, London, 1904, vol. ii, p. 745): "The Kavirondo blacksmiths use a bellows which is made out of a whole log of wood converging to a point. This point is inserted into a clay funnel. The log is really the section of the trunk of a small tree cut above and below its bifurcation. The two biggest branches are retained and when the whole of the wood has been hollowed out it gives a central pipe with two branches. At the end of the openings of the branches a goat-skin is loosely fastened. This skin is puckered up into a point in the middle, to which is fastened the end of a long, light stick. Each of these sticks being worked with a piston action, the air is sent through the central tube and the clay nozzle into the glowing charcoal." Frequently the body of the bellows is constructed out of pottery, while the air-delivery consists of a hollow branch ending in a pottery nozzle. Charcoal is invariably used for fuel, and as a reducing agent.

When ore is smelted on (for the native) a comparatively large scale, the method employed is as follows: Proceeding to the locality where ironstone is known to exist, work is commenced by digging until ironstone is reached. If the stone is so hard as to be unbreakable, a large and fierce fire is built over it. This fire is allowed to burn until the stone is split and splintered by the heat. When cool the splintered portions are taken away for breaking up. These portions are placed in a separate hole, and then broken up into small pieces by a native hammer or a hard round stone. The iron ores are then picked carefully out and the impure residue is thrown away. A hole some 2 ft. to 3 ft. in depth is sunk in the ground. The size of the hole depends on the amount of ore to be treated. A fire is started in this hole, and when sufficiently hot is fed by charcoal until the hole is filled to the level of the ground surface. The small pieces of ore are tied into bundles made of grass measuring 2 ft. to 3 ft. in length, and these bundles are placed all round the sides of the hole end-ways on so that about three-quarters of their length remain aboveground and the other quarter beneath the charcoal. In equal distances round the hole on the same level as the ground and with their points protruding into the hole, eight or more native bellows are placed, the number of bellows depending on the size of the hole. Clay is brought and is plastered thickly from bottom to top against the outside of the standing bundles; this keeps both the bundles and bellows firmly fixed. More charcoal is added until the level of the top of the bundles is reached; on the top of this are placed dry lumps of earth built into the shape of a dome. This in turn is clayed over, only leaving an air-hole at the top. This hole serves two purposes, first to allow the smoke fumes to escape, and second to allow the addition of charcoal if necessary. A period of twenty-four hours or so is allowed to elapse before forging commences; this is to allow the clay to set firmly. The bellows are then worked unceasingly from 6 a.m. to 2 p.m. The bellows are then taken from their position and the clay walls and roof are dismantled. The pure iron is lifted out while still very hot, and placed in another hole covered with earth and left to cool. Having cooled, it is in due course stored till required for use.

Except in the Masaka and Mubendi districts no smelting from ore is done in the Buganda Province. The Buganda smiths merely melt up scrap and beat it out afresh. There is plenty of evidence, however, to show that ore-smelting was more widely practised in bygone days. In Lango, again, in the Eastern Province, ore-smelting is only done by Bunyoro people at one spot, Kagaga Hill. The Lango people themselves never use ore and only melt up scrap for the purpose of making personal ornaments and charms. They purchase all their tools from the Banyoro. The case of Busoga (Eastern Province) is similar to that of the Entebbe and Mengo districts of Buganda. The Basoga use only scrap iron ore smelted ore obtained from the Kavirondo and Banyoro.

(To be continued.)

THE MIGRATION AND ACCUMULATION OF OIL

In *Economic Geology* for October, John L. Rich contributes an important paper describing a theory of the cause of the migration and accumulation of oil and gas. He holds that moving underground water is the primary cause, thus providing a working theory in place of the buoyancy theory which, though known to be weak, has held the field in absence of any other. We quote herewith extracts from his lengthy paper.

The theory that oil moves up the dip of the rocks into the anticlines mainly on account of its buoyancy as compared with water still seems to have many adherents, in spite of the fact that it has repeatedly been shown that the component of gravity tending to cause a globule of oil to move up the dip of the rocks is much less than the static friction opposed to its movement. Repeated experiments, also, by various investigators have shown that no movement takes place, even vertically upward through the sands, unless the liquids are agitated in some way or unless moving gas is present. As a result of the inadequacy of the theory of pure gravitational migration, a number of geologists have suggested other causes for movement and accumulation.

Roswell H. Johnson has stated that it is probably necessary that a relatively large globule should form before movement can start, because, on account of surface tension, oil cannot move until the bubble grows so large as to extend a bud through one of the larger passageways into the adjoining chink between grains. Johnson has also argued that the squeezing of water out of the sediments during the process of compacting, as well as the expulsion of liquids on account of the generation of gas in the deeper rocks, would cause upward movement of the rock fluids together with any disseminated oil and gas which they might contain. A. W. McCoy is led, from the results of his experiments, to believe that, in general, oil does not migrate for great distances and is mostly accumulated near its source of origin, mainly by capillary forces. E. W. Shaw and M. J. Munn, in several of their reports on the Appalachian fields, called attention to features which did not seem to be explained by the then prevailing theory of segregation due to buoyancy. Later, Munn developed the well-known "hydraulic theory." Certain features of this theory, especially the idea that the location of the oil pools is due to bodies of oil becoming trapped and held—partly by capillarity—between advancing water currents, seem to have prevented its general acceptance, though Munn's work did much to advance the idea of the importance of moving water as an oil-carrier. More recently, M. R. Daly has urged that the movements of rock fluids caused by deformation are the most important causes of oil migration and accumulation. The fluids, including disseminated oil and gas, are supposed to be squeezed out of the zones of greatest compression and concentrated farther from the sources of thrust pressures in belts where the compression is less intense. Since the crests of anticlines, above the neutral zone, would be places of relative tension, the common association of oil with anticlinal structures is accounted for.

Shaw, in connexion with his discussion of a number of papers, has repeatedly mentioned and partly developed the idea that moving underground water, due to simple artesian circulation, and to slow downward percolation of water into the great geo-synclines, has carried with it oil and gas which has been segregated in favourable places under the influence of selective buoyancy He has suggested that, where water movement is relatively rapid, oil and gas may both be completely flushed out of the structure, while with a little less rapid movement gas, only, may be trapped, the oil being more readily carried along and flushed out by the water. Mr. Rich acknowledges his indebtedness to Shaw, who, in conversation, first convinced him of the importance of the rôle of circulating water, and thereby furnished a key to an understanding of many peculiarities of the occurrence of oil and gas which he had noted, or which had been pointed out to him, but which were not satisfactorily explained by the prevailing theories. On the basis of the ideas of Shaw and Munn, carried out to their logical conclusions, Mr. Rich has developed his theory of the hydraulic migration and accumulation of oil and gas. In its broader aspects, the theory is a somewhat modified form of Munn's "hydraulic theory."

To put Mr. Rich's theory briefly, it may be said that in his view the principal cause of the migration of oil and gas is the movement of underground water, which carries with it minute globules of oil and bubbles of gas, possibly as fast as they are formed; and that accumulation results from the selective segregation of oil and gas, which, on account of their buoyancy, always tend to work their way upward, not necessarily up the dip, but up towards the roof of the containing reservoir, as they are carried along and are caught and retained in anticlinal or other suitable traps. The nature of the trap necessary to cause accumulation depends on the rate of movement of the water and the corresponding texture of the sand or other medium through which it flows. Where the sands are porous and there is a strong hydraulic head, a sharp anticline with large closure is necessary to retain the oil; in fact, where the movement is especially rapid, even such a structure may be inadequate. Where the sands are fine and the water movement is slow, slight structural and textural variations are enough to arrest the movement of the oil and gas. Under such conditions broad, flat anticlines with very little closure, terraces, or even minor flattenings of the regional dip are enough to cause accumulation. It would seem to be unnecessary to argue for the widespread movement of underground waters under the influence of gravity and differences of head, yet petroleum geologists, as a rule, appear to have ignored this movement. The well-known facts of artesian circulation through distances of hundreds of miles admit of no dispute.

As an example Mr. Rich takes the case of a widespread bed of sandstone lying between petroliferous shales. Whatever the origin of the oil, nearly all are agreed that, by one process or another, a considerable part of it will find its way out of the shales into the porous sandstone. All will probably agree, also, that it must enter the sandstone very gradually in the form of minute globules, probably of microscopic size. Such a sandstone is almost certain to be a channel of water circulation. The question is what will become of the oil after it enters the sandstone, and whether its movement will be controlled by buoyancy alone, irrespective of the water movement, or by the motion of the water into which it enters. According to the old idea of up-dip movement on account of difference in specific gravity between oil and water, the tiny oil globule will work its way up the dip of the sandstone, even though the dip be as low as 10 ft. per mile, and even against a downward artesian flow of the water in the sand. In view of the results of repeated experiments and of the calculations mentioned above, this is surely an absurdity. The specific gravity of oil is so near to that of water that oil is very easily carried along in a water current, even if the movement is very slow, just as a piece of wood is carried along by a river. To expect a block of wood to float upstream on account of its buoyancy would be about equivalent to expecting a minute globule of oil to work its way up the dip in the face of an opposing water current. If the oil globules are relatively large as compared with the size of the openings between the sand grains of the reservoir, there must be a lower limit of velocity beyond which the water current is unable to move them against the friction opposing their motion. The same velocity of movement which would fail to carry a globule of a given size would, however, suffice to carry a smaller one, and so on down to the smallest sized globule that can be conceived. Since the oil and gas globules as they are first formed and first enter the sand are undoubtedly exceedingly small, it is not necessary to suppose that an exceptionally rapid water flow is necessary for their transportation.

Mr. Rich discusses the methods of segregation of oil and gas from moving water, and concludes by saying that the anticlinal theory, in so far as it implies that buoyancy is a prime cause of the movement of oil through rocks, is founded on a false premise. Nevertheless, the fact remains that most of the world's oil so far discovered is on anticlinal structures. Like many others, the anticlinal theory in its original form was a half-truth. Buoyancy, it appears, though unable of itself to move oil through sands as fine as the ordinary oil sands, is the agency which, by its selective action on oil and gas moved through the sands by other agencies, causes the segregation and accumulation of these substances in anticlinal and other suitable traps. Buoyancy, however, is not the only force which causes segregation. Capillarity is also effective. Since anticlines are the simplest and most common traps, the success of the anticlinal theory in practice seems to have blinded most geologists to the fallacy on which it is based.

The Ballarat School of Mines and Industries.—The *Industrial Australian and Mining Standard* for October 20 contains a description of the Ballarat School of Mines and Industries. This article is one of a series dealing with modern technical education in Australia. It may be read to advantage in connexion with the article by Mr. Harris elsewhere in this issue. It is claimed that no educational institution is better known throughout Australia than the Ballarat School of Mines and Industries. It was the late J. M. Bickett who brought forward the proposition to found the school at a meeting of the Ballarat Mining Board in October, 1869. It was agreed to, and the Government, having been approached for assistance, granted a lease of the old Supreme Court buildings at a nominal rental. A modest sum, including £100 from the Borough Council of Ballarat West, was subscribed by a number of sympathizers, and on October 26, 1870, the inaugural address was delivered by Sir Redmond Barry, the first president of the school. Classes were commenced on January 23, 1871. Among those who gave advice and encouragement was Sir Roderick Murchison, who many years before had advised Cornish miners to emigrate to Australia to search for gold, and who, in 1848, was in possession of gold ore sent from Australia. Sir Roderick sent a parcel of books for the library, and gave useful advice as to the curriculum which should be adopted. The students at first were mostly adults. They were chiefly men employed at the mines, who had the wisdom and energy to devote their spare time to study, and, though their attendance was somewhat irregular, they made good progress. Old prints which have been preserved show them at work at the furnaces, big bearded men of the old-fashioned type of gold miner. With this commencement, the School continued for several years to concentrate its resources and energies on mining and metallurgical education. The entire mining district, with its mines and works, constituted a vast and permanent object lesson for the School's use and an ever active source of inspiration to the student. Attracted by so many advantages, students came from overseas as well as from every Australian state, and having gained their diploma or certificate took with them the name and fame of the school to every mining field in the world, many of them holding important and lucrative positions.

In 1882 the number of students had risen to 96, and in order to accommodate this large increase, the building formerly used as a Methodist Church was taken over by the council. Although the primary aim of the founders was to give instruction in mining and its allied subjects, the School had always kept in touch with industrial developments in Ballarat. It therefore readily adapted itself to the new conditions when manufacturing began to displace mining as the principal local industry. As a result many new subjects were added to the curriculum, and in order to meet the demand for new laboratories and lecture rooms, a large new building, now known as the Science School, was opened on May 18, 1900, the foundation stone having been laid by Sir Alexander Peacock on April 14, 1899. One of the most interesting and successful branches of the School of Mines and Industries is the Technical Art School. "The City of Statues" has from its earliest days been a stronghold of art, and its Art School had long established for itself a record as the leading institution of this kind in Australia. It was inaugurated by the Council of the Fine Art Gallery Association, and was for some years governed by that body. Recognizing that the interests of the School of Mines and the Technical Art School were so closely associated, the Education Department decided to amalgamate the two institutions, and in 1905 the Art School was placed under the management of the School of Mines' Council. A new Technical Art School was built at a cost of £12,000 on the site of the old Supreme Court building, and was formally opened on July 23, 1915. The School has developed education in arts and crafts with the same success that the School of Mines has pioneered the way in science and engineering.

In 1914 the research laboratories in chemistry, metallurgy, and assaying were rebuilt and newly equipped. Batteries, furnaces, cyanide plant, and various types of mills and concentrators are installed, and are periodically working throughout the year. New laboratories in electrical science have also been recently added. The geological, engineering, hydraulic, physical, and mineralogical laboratories were at the same time enlarged and equipped to carry students through the most advanced sections of their practical work. The mechanical engineering laboratory is well fitted up with the most up-to-date machinery, consisting of many excellent lathes, drilling, and testing machines, working models, and experimental engines.

The Junior Technical School is the most recent addition to the School of Mines and Industries. It gives preparatory technical training to boys from 13 years of age, and takes up their education where the Primary Schools leave it. Its students are drawn principally from the elementary State schools, and they must have obtained the qualifying or merit certificate before they can be admitted. The course of instruction occupies two years, and provides a thorough grounding for the diploma courses of the Senior School.

During the past three years the vocational training of returned soldiers has occupied a prominent place in the activities of the School. The work was taken in hand by the Council before the Repatriation Department gave assistance, and now, with the help of that department, the School has become one of the largest vocational training centres in Victoria outside of Melbourne. The soldiers, trained in a variety of occupations, have made remarkable progress, and already considerable numbers have found employment in local workshops and factories.

Mention should also be made of the series of the industrial researches which are being continued under the supervision of the Principal, Mr. A. F. Heseltine. The investigations regarding the suitability of some local ores for the manufacture of pigments attracted much attention, while the experiments on the manufacture of white earthenware from Victorian clays were considered of sufficient importance by the Federal Advisory Council of Science and Industry to warrant the appointment of a special investigator.

It should be added that the principal is a graduate of the University of Adelaide and of the South Australian School of Mines, and has had a very large and varied experience of mining and metallurgy.

Electrolytic Iron.—In *Mining and Metallurgy* for December, C. P. Perin and D. Belcher describe the process for making electrolytic iron direct from ores without the use of the blast-furnace, invented by F. A. Eustis, of Boston. This differs from methods previously employed for the electrolysis of ferrous chloride, in that an insoluble anode is used. The iron is deposited on a rotating cathode, but a diaphragm separates the anode and cathode compartments. At the anode an oxidation of ferrous chloride takes place and, by keeping a hydrostatic head on the catholyte, diffusion is reduced to a minimum. The researches on this process were carried on at the Massachusetts Institute of Technology by Professor C. R. Hayward, in conjunction with H. M. Schleicher and Donald Belcher. The ores used have been mostly sulphide, particularly pyrrhotite. The ferric chloride formed in the anode compartment fo the cell is led over the sulphide ore, thus reducing the ferric chloride and effecting the solution of iron at the same time. Sulphur deposited in the gangue is recovered as brimstone. Any copper that is dissolved must be removed by precipitation on scrap iron, and offers another by-product. The ferrous chloride in then electrolysed with the production of iron and ferric chloride. The cell reaction is: $3FeCl_2 = Fe + 2FeCl_3$. The ferric chloride brought into contact with the ore reacts as follows: $2FeCl_8 + FeS = 3FeCl_2 + S$. It is apparent that exactly the amount of iron is restored to the solution that was removed by electrolysis. Thus the process is cyclical. The above reaction is exothermic to the extent of 20,400 calories, and thus the leaching action is materially assisted.

By proper temperature control, the free sulphur formed in the reaction may be caused either to sink with the gangue or to float at the top. Counter-current extraction has led to 97% recovery of the iron content of the ore, and 90% of the sulphur. Pyrite and oxide ores may be used instead of pyrrhotite, but these require more special treatment. Properly controlled, there is no chlorine gas given off during electrolysis, hence no chlorine is lost in this manner, and no free acid or noxious vapours are formed. The cathode current efficiency is 90% or more; at the anode the reaction is quantitative. The process uses no solid fuel, and therefore enters into direct competition with electric-smelting operations, but with the advantage that the expenditure of electrical energy per ton is much less. From 3 to 4 tons may be made per horse-power-year.

A sample of the iron was submitted to Andrew S. McCreath & Son, of Harrisburg, for chemical analysis, and their report was as follows:—

	Per cent.
Sulphur . .	0·002
Silicon . .	0·002
Phosphorus .	0·0016
Carbon . .	Trace (not over 0·003)

This would show the iron to be more than 99·99% pure, probably the purest iron on record.

A number of tubes have been made by this process. The iron of these tubes is most compact, consisting of a fine network of ferrite crystals; its resistance to atmospheric corrosion as compared to wrought iron and low-carbon steel is marked. Tests made in 5% sulphuric acid at room temperature showed wrought iron to corrode nearly 20 times as fast as electrolytic iron.

Pure iron is desirable in making special steels, boiler tubes, electric motors, generators, transformers, telegraph wire, and for many other purposes. It has unusual mechanical and electrical properties which open up many special fields. Moreover, it may be used to replace iron or steel in sheets and tubes on a purely price-competition basis.

The Machine in Mining.—At a joint meeting of the National Association of Colliery Managers and the Association of Mining Electrical Engineers, held in Glasgow on November 12, David C. Gemmell delivered an address, entitled "A New Aspect of Machine Mining." His view that the introduction of machinery dulls a man's intellectual interest in his work and causes him to desire shorter hours and more opportunity for amusement, is deserving of consideration by those who are attempting to find a reason for the slacking of the miner, though no doubt many will regard his view with incredulity and even astonishment. As he has practical suggestions for making machine work more attractive, his paper is well worth reading, and we give herewith extracts showing his main points.

Most of the many papers written on machine mining deal with the advantages that must accrue to the colliery which adopted machines, and it would almost appear to be heresy to even suggest that there is another aspect of machine mining. However, the author said he would like to touch upon the subject from the human point of view, and would ask what effect the introduction of machinery at the faces of the mines had upon the character and abilities of the workers there. It is interesting to recall the type of men employed at the coal face of the mines say over twenty years ago. At that period coal mining was skilled labour, and the miner himself a craftsman. His work may have been arduous, but it had variety and interest enough to make it necessary for him to use his brains. He had to perform the whole cycle of operations incidental to coal-getting himself. Specialization had not then invaded the industry, and the average miner could turn his hand to almost any of the various operations that went to the production of coal. He had the natural pride of a skilled artizan, and although no apprenticeship was formally arranged, the young lad entering the mine had to pass through the recognized course before he was competent to take over a working place for himself. Compare this man with his successor to-day. Apart from the few trained workmen at special occupations, the face worker of to-day has deteriorated into an unskilled labourer.

While mechanical undercutting of coal may have relieved the miner of the most strenuous part of his labour, it has also left the part which requires least skill for its performance. Can anyone imagine a more monotonous, treadmill-like occupation than the filling of machine-cut coal into a conveyor? The performance of this kind of labour, week in week out, is leaving a deep and indelible mark upon those who are called upon to perform it. The lowering of the standard of skill required to perform a job must inevitably have the result of driving away men of a higher standard of intelligence from it. It would be gross exaggeration to suggest that the introduction of machine mining has been the cause of that violent type of unrest prevailing in the industry, but the author claims that it has been a contributory cause of no mean importance. It has at least tended to create that state of mind necessary to imbibe the half-cooked ideas so freely propounded to-day. The absurd length to which specialization can be carried is a menace to the prosperity of the mines. The miner will continue filling coal till he loses the ability to do anything else; the machineman refuses to timber the face; the shot-firer will only fire shots, and the electrician, while he repairs the motor-end of a coal-cutter, declines to look at the gear-box. Almost the only all-round man at the colliery who has not had his duties subjected to demarcation either by the rigid rule of a trade union or by the almost as powerful rule of "use and wont" is the manager himself. The author is anxious that no one should think he is advocating that the hands of the clock should be set back, and that they should return to the days when coal-cutters and conveyors existed only in the imagination of some optimistic pioneers. He believes that machinery is essential to the winning of coal, and that it will become more and more so. What he attacks is the system of application.

The coal mining industry is faced with a crisis such as never confronted it before. Costs must be reduced so that the industries of the nation may be restored. Other means than wages cuts must be adopted if the prosperity of the nation is to be restored. The only method is to increase the efficiency of the industry and secure a higher output per individual. In certain circles there is an optimistic belief that the miners may agree to an increase of working hours, but the writer does not share that belief, and considers that nothing would be more strenuously resisted by the miners than any increase in the hours of labour underground. At the most, any increase of hours which could be obtained cannot alone materially alter the position. The only remedy would be to double-shift the pit, but with the present system of coal-cutting this is impracticable. It might be suggested that the depth of the undercut should be increased to enable coal to be drawn on two shifts instead of one, but the writer has rarely met with an instance where such was feasible. He is of opinion that the present methods of machine mining stand in the way of increased outputs, and he offers suggestions which may increase the human interest and the output. His suggestions are calculated to remove the lopsided nature of the miner's occupation and to result in an increased individual output from machine-worked collieries.

To make clear the character and scope of the suggestions, the writer takes the specific case of a colliery with an output of 500 tons per day. This may be the product of six or eight machines, and each machine may be cutting on an average eight places. Instead of employing the large and cumbersome machines in use to-day, there should be used a much smaller and lighter machine, capable of cutting two or three places in three or four hours. Such a machine does not yet exist, but there are firms of machine-makers enterprising enough to design and manufacture such machines if there is a demand for them. Allocating two places to each machine—the number might be more, but this will suffice for the present purpose—each of these pairs of places is manned by a squad of workers whose duties include cutting, stripping, and the other incidental operations. All the operations may be carried on practically simultaneously, the actual stripping closely following the cutting. Another such squad of men would follow on the succeeding shift, the face being cut and cleared twice during the 24 hours and leaving ample time for brushing. Each squad should have a responsible leader, the work being done on piecework. Men engaged in these squads would require to do all classes of work, and there would be an opportunity for them acquiring that all-round ability that specialization has banished from the mines. The cost should be no more for labour, and economies would be effected through the rapid moving face and the greater output. The writer replies to some possible objections which may be urged against the adoption of the method advocated.

(1) It might be said that the greater amount of capital required for coal-cutters would render the scheme unprofitable. The answer was that capital expenditure must be considered in relation to output, and this system would give greater output for given outlay.

(2) It might be said that there would be greater liability to breakdowns due to the multiplication of machines. In this connexion it must be remembered that the breakdown of a machine would not be the serious matter it was now.

(3) It might be urged that there was a scarcity of skilled labour. This already existed, and it was not to the credit of the industry that it did. The scheme suggested would give a better training to the young lads entering the mines.

SHORT NOTICES

Winding Engine.—The *Colliery Guardian* for December 9 prints a paper on the Ward-Leonard winding plant at the Isabella colliery, Durham, read recently by J. T. Pringle before the junior section of the North of England Institute of Mining and Mechanical Engineers.

Sampling Methods for Diamond Drills.—A paper on sampling methods useful in connexion with diamond-drill cores will be presented by R. D. Longyear at the February meeting of the American Institute of Mining and Metallurgical Engineers.

Conveying Plant. — At the meeting of the Institution of Mechanical Engineers held on December 16, Gardiner Mitchell read a paper on conveying and elevating machinery.

Dredge Buckets.—In the *Engineering and Mining Journal* for December 10, G. J. Young describes recent forms of lips for dredge buckets.

Historical Engineering. — The *Engineer* for December 16 prints a paper read before the Newcomen Society by R. C. Skyring Walters, entitled "Greek and Roman Engineering Instruments." This paper gives an account of ancient surveying instruments.

Fine Grinding.—At a meeting of the Ceramic Society, held on November 7, J. C. Farrant read a paper entitled "Closed-circuit Grinding," giving particulars of the application of the Hardinge mill to fine grinding for the purpose of preparing pottery materials.

Measurement of Fine Particles.—The *Journal* of the Franklin Institute for November contains a paper by Henry Green describing a photomicrographic method for the determination of the size of fine particles such as are necessary in materials used as pigments.

Coal Washing.—At the meeting of the Midland Counties Institution of Engineers held on December 10, A. France-Focquet read a paper on the "rheolaveur" coal-washing process.

Reverberatory Practice.—The *Engineering and Mining Journal* for November 26 contains an account of the history of the side-charging of reverberatory furnaces.

Electrolytic Zinc.—The *Journal of Industrial and Engineering Chemistry* for December contains an article by H. V. Tartar and H. E. Keyes discussing the electrical conductivity of zinc sulphate solutions.

Electrolytic Zinc.—The *Journal* of the Society of Chemical Industry for December 15 prints a paper by Motohiro Namba describing experimental work done in Japan in connexion with the electrolytic treatment of low-grade zinc ores.

Metallurgy at Cobalt.—In the *Engineering and Mining Journal* for December 3, H. E. Cawley describes the treatment of old slime containing 6 oz. of silver per ton at the Coniagas mine, Cobalt, Ontario.

Genesis of Ores.—At the meeting of the Chemical Society held on December 8, Professor J. W. Gregory read a paper on the Genesis of Ores.

Geological Studies at Homestake. — In the *Engineering and Mining Journal* for December 3, L. B. Wright and J. O. Hosted described the methods of geological investigation at the Homestake gold mine, Dakota.

Syrian Minerals.—In the *Engineering and Mining Journal* for November 26, I. M. Toll describes the mineral resources of Syria.

Iron Manufacture in Brazil.—In *Chemical and Metallurgical Engineering* for December 7, N. A. V. Paulsson describes an electric iron and steel plant under construction at Ribeirao Preto, in the province of Sao Paulo, Brazil. The ore is smelted electrically by the Swedish process.

Queensland Geology.—The *Queensland Government Mining Journal* for October prints an article by Dr. H. I. Jensen describing the geology of the Carnarvon Range, South Queensland. As regards mineral deposits the prospects for oil and coal are of interest.

Synthetic Ammonia.—At a joint meeting of the Institution of Mechanical Engineers and the Society of Chemical Industry held on November 22, J. H. West read a paper describing the Claude synthetic ammonia process.

Oil in Colombia.—*Economic Geology* for November contains a paper by E. Back on the geology and oil resources of Colombia.

Sumatra Petroleum.—In the *Engineering and Mining Journal* for December 10, A. H. Redfield describes the Djambi oilfield, Sumatra.

Hydro-electric Power. — The *Engineer* and *Engineering* for December 6 contain descriptions of the new project for increasing the water-supply to the town of Bradford, derived from the Nidd Valley, the novel point being that some of the water is to be used for the generation of electric power before being delivered to the conduits.

Reinforced Concrete Pipe.—The *Iron and Coal Trades Review* for December 16 describes the manufacture of the Hume reinforced concrete pipe at the works of the Stanton Ironworks Co., Ltd., Dartford, Kent

Air and Gas Measurement.—At a meeting of the Midland Institute of Civil, Mining, and Mechanical Engineers held on December 10, J. L. Hodgson read a paper on the measurement of large volumes of air and gas by means of the Venturi tube.

RECENT PATENTS PUBLISHED

☞ *A copy of the specification of any of the patents mentioned in this column can be obtained by sending 1s. to the Patent Office, Southampton Buildings, Chancery Lane, London, W.C. 2, with a note of the number and year of the patent.*

12,386 of 1920 (156,561). R. WALTER, Düsseldorf. Method of making acid-resisting alloys of silicon with iron, chromium, and similar metals.

12,706 of 1920 (170,884). A. J. FRANCOIS, Doncaster. Improved way of arranging the iron reinforcements for concrete linings for mine workings.

13,570 of 1920 (143,525). J. W. MOFFAT, Toronto. Reducing iron, cobalt, and manganese from their ores at low temperatures without melting, and then sending the reduced metal for melting and refining in an electric furnace.

14,484 of 1920 (171,722). C. E. CORNELIUS, Stockholm. In zinc distilling cooling the metallic vapours so as to precipitate it all as powder and then liquefying the powder in a melting furnace.

18,378 of 1920 (146,396). E. OTSUKA, Tokyo. Modifications of the arrangement of frothing beaters of the horizontal type, such as are used in the Kollberg and Kraut flotation machine.

19,016 of 1920 (147,052). P. SCHERMULY, Frankfurt-am-Main. Modifications in the inventor's divining rod.

19,654 of 1920 (147,672). A. STAPF and H. HUNDRIESER, Berlin. Core drill with a telescopically collapsible feed whereby the drill may be retracted to encase the feed rod and thereby effect a saving in the size of the apparatus.

19,663 of 1920 (147,660). A. STAPF and H. HUNDRIESER, Berlin. A hollow rock-drill with blades adjustably mounted in a crown head, the crown being slidably mounted on the core barrel of the drill, and provided with axially or obliquely arranged window-like recesses having slidably engaging members adapted to engage and be held in position by the core-barrel, the members serving as holders for the drill blades.

19,705 of 1920 (149,662). VEREIN CHEMISCHER FABRIKEN IN MANNHEIM, Mannheim. Method of making sulphurous acid from gypsum or from magnesium or iron sulphate by heating the sulphate in the presence of a heavy metal, such as iron, with carbon or a reducing gas, conducting the operation in a neutral atmosphere or in a vacuum.

20,368, 20,822, 20,843, and 20,844 of 1920 (148,421, 148,962, 148,983, and 148,984). GESELLSCHAFT FÜR NAUTISCHE INSTRUMENTE, Kiel. Method of keeping bore-holes in the desired line.

20,521 of 1920 (148,538). SPRENGLUFT GESELLSCHAFT, Charlottenburg, Berlin. Method of making blasting cartridges employing liquid air.

21,800 of 1920 (170,912). A. FRANCOIS, Doncaster. Forming a plug at the bottom of a shaft into which water flows, by suspending pipes to near the bottom to introduce liquid cement and then filling the bottom of the shaft with ballast which will form the basis of a concrete plug.

22,763 of 1920 (170,944). L. A. WOOD, W. G. SELLERS, and MINERALS SEPARATION, LTD., London. In the use of tar and tar-oils as frothing agents in the flotation process, giving these substances a preliminary treatment with an emulsifying agent, such as a caustic alkali.

23,162 of 1920 (171,155). W. BROADBRIDGE and E. EDSER, London. Concentrating low-grade phosphates by flotation before treating with sulphuric acid to make a fertilizer.

24,047 of 1920 (171,490). METALLURGISCHE GESELLSCHAFT, Frankfurt-am-Main. Refining lead, tin, or other metals by introducing sodium, calcium, or magnesium at comparatively low temperatures, which alloy with the impurities without any volatilization.

24,579 of 1920 (172,087). D TYRER, Stockton-on-Tees. Method of extracting alumina from clay by calcining with lime without the addition of alkali, in such proportion that there are present at least two molecules of lime for each molecule of silica and also at least one molecule for each molecule of alumina, heating the mixture to a certain temperature, and then treating the mass with a solution of an alkali compound, thus obtaining an alkali aluminate.

24,847 of 1920 (151,259). NORSKE AKTIESELSKAB FOR ELEKTROKEMISK INDUSTRI, Christiania. Method of producing pure alumina from aluminium nitrate.

24,924 of 1920 (172,101). W. G. PERKINS, London. In the treatment of complex ores containing iron sulphide, giving the latter a coating of magnetic material by exposure of the crushed ore to the action of superheated steam, and removing the magnetic material by a magnetic separator.

27,085 of 1920 (171,014). H. BERNAY, San Francisco. In rock-drills improved means for detachably mounting the bit within the chuck.

27,255-6-7 of 1920 (171,266-7-8). E. G. WEDDELL. Improvements in coal washers of the type in which an ascending stream of water is employed.

28,520 of 1920 (171,859). H. H. THOMPSON and A. E. DAVIES, Birmingham. In magnetic separators of the trough or tray form, in which the material is passed over magnet poles or iron bars magnetized by magnets below, the combination with the magnet poles or bars of armature pieces of iron or steel arranged above or spaced away from the magnetic surfaces so as to permit the passage of the material.

7,425 of 1921 (159,887). E. LIEBREICH, Berlin. Method of precipitating chromium electrolytically.

11,452 of 1921 (171,944). G. H. T. RAYNER and P. RAYNER. Valve apparatus for rock-drills.

NEW BOOKS, PAMPHLETS, Etc.

☞Copies of the books, etc., mentioned below can be obtained through the Technical Bookshop of *The Mining Magazine*, 724, Salisbury House, London Wall, E.C. 2.

The Mineral Industry : Its Statistics, Technology, and Trade during 1920. Founded by R. P. ROTHWELL ; edited by G. A. ROUSH and ALLISON BUTTS. Cloth, octavo, 927 pages, illustrated. Price £2 15s. New York and London : The McGraw-Hill Book Company.

The Historic Geography of the Wealden Iron Industry. By M. C. DELANY. Octavo, paper covers, 62 pages, illustrated. Price 4s. 6d. London : Benn Brothers, Ltd.

Preparation, Transportation, and Combustion of Powdered Coal. By JOHN BLIZARD. Octavo, paper covers, 132 pages, illustrated. Ottawa ; The Department of Mines.

Gas Producer Trials with Alberta Coals. By JOHN BLIZARD and E. S. MALLOCH. Octavo, paper covers, 40 pages, illustrated. Ottawa : The Department of Mines.

Converting a Business into a Private Company. By H. W. JORDAN. Cloth, small octavo, 48 pages. Price 1s. London : Jordan & Sons, Ltd.

Mining : Highest and Lowest Prices, Dividends, etc., for the Past Six Years. Pamphlet, pocket size, 110 pages. Price 2s. London : Fred. C. Mathieson & Sons.

Year - Book of the Scientific and Learned Societies. Cloth, octavo, 366 pages. Price 15s. London : Charles Griffin & Co., Ltd. This is the thirty-eighth annual issue of a most valuable book, which contains a list of all the learned societies in Great Britain and Ireland, with particulars of their constitution and personnel and accounts of the papers and reports issued by them during each succeeding year.

COMPANY REPORTS

Van Ryn Gold Mines Estates.—This company has worked an outcrop property in the Far East Rand since 1892. Sir George Albu is the managing director, and E. G. St. John is the manager. The report for the year ended June 30 last shows that 472,049 tons of ore was raised, and after sorting, 381,230 tons was milled. The yield of gold by amalgamation was 75,541 oz., and by cyanide 33,325 oz., making a total of 108,866 oz., equal to an extraction of 5·71 dwt. per ton. The gold realized £604,147, or 31s. 8d. per ton, and the working cost was £491,291, or 25s. 9d. per ton, leaving a working profit of £112,855. After the deduction of taxes and the addition of several items of revenue, the net profit was £90,393, from which, again, was deducted £11,841 for depreciation of plant. The shareholders received £75,000, the dividend being at the rate of 15%. It will be seen that but for the gold premium there would have been a substantial loss. The ore reserve is estimated at 864,583 tons, averaging 6·1 dwt. per ton. These figures are based on the standard value of gold, and a further 393,056 tons could be included in the reserve if the price of gold was 112s. 6d.

Sub-Nigel.—This company belongs to the Consolidated Gold Fields group, and was formed to work properties in the Heidelberg district of the Transvaal in 1895. No milling was done by the company until 1909, when the property of the more successful Nigel Deep was acquired. Claims on the dip were acquired in 1914, 1916, and 1918.

The report for the year ended June 30 last shows that after the removal of 17% waste at the sorting station, 118,200 tons of ore was sent to the stamps. The yield of gold by amalgamation was 36,054 oz., and by cyanide 34,166 oz., making a total of 70,220 oz., equal to an extraction of 11·88 dwt. per ton. The gold realized £389,187, of which £93,926 represented premium, making the yield per ton worth 65s. 10d., of which 15s. 10d. represented premium. The working cost was £288,910, or 48s. 10d. per ton, leaving a working profit of £100,277, or 16s. 11d. per ton. The dividend absorbed £87,187, being at the rate of 11¼%. Of the reef disclosed in development work during the year, 19% was payable, averaging 60·8 dwt. over 9·2 inches. The reserve at June 30 was estimated at 243,000 tons, averaging 10·3 dwt. over a stoping width of 43 in.; in addition there was 33,000 tons of an indicated value of 11·3 dwt. per ton. No payable ore has yet been discovered on the 22nd or bottom level.

Zaaiplaats Tin. — This company has been working tin mines in the Northern Transvaal since 1908. The report for the year ended July 31 shows that mining had to be suspended on March 17, 1921, owing to the low prize of tin. During the time the mill was running 10,150 tons of ore and 1,626 tons of accumulated tailing were treated for a yield of 217 tons of tin concentrate. At the Stavoren property 480 tons of ore gave 7½ tons of concentrate. The yield of concentrate from 69,931 tons of alluvium was 25½ tons. Also 43 tons of concentrate was purchased. At the smelting plant 140 tons of metallic tin was produced. The accounts show an income of £34,142, and an adverse balance of £13,188. A limited amount of development work continues to be done, and some of the old dump material and also alluvium is being treated, so as to provide sufficient income to keep the mine and works in order, the concentrate produced being sent to Malaya for treatment.

Rooiberg Minerals Development.— This company belongs to the Anglo-French Exploration group, and has operated tin mines in the Northern Transvaal since 1908. The report for the year ended June 30 last shows that 27,745 short tons of ore, averaging 1·63% metal, was sent to the mill, where 500 long tons of tin concentrate was extracted. The washing of 35,409 tons of alluvial ground yielded 66 tons of concentrate. The total revenue was £66,387, and balance of profit £650. Since the end of the company's year it has been decided to suspend mining until the price of tin recovers. The alluvial ground will, however, still be treated, and also the accumulated sand and slime. Developments continue to give good results.

Middleburg Steam Coal and Coke.—This company has operated coal property in the Middelburg district of the Transvaal since 1902. The report for the year ended June 30, 1921, shows that the output of coal was 331,795 tons, figures almost identical with those of the previous year. Owing to high railway charges and other causes it has been difficult to secure profitable bunkering and export orders, but the Government has partly met the position by making a reduction in the rates. The company has increased its holding in the Station Colliery Company, and now holds 45,621 shares out of 60,000. The trading profit for the year was £23,130, out of which £8,477 has been allocated to tax accounts, £830 has been paid as debenture interest, and £3,244 as preference dividend. No dividend is paid on the ordinary shares, owing to the necessity of rehabilitating the plant which could not be kept in first-rate order during the war, and also owing to the purchase of certain freeholds. The new incline shaft has been completed, and is in commission, and the company will now be able to increase its output.

Wankie Colliery.—This company has worked coal deposits in Rhodesia, 200 miles north-west of Bulawayo, since 1899. Edmund Davis is chairman and managing director, and A. R. Thomson is manager. The report for the year ended August 31 shows that 314,124 tons of coal and 123,135 tons of coke were sold. The profit was £69,986, out of which £56,733 has been paid as dividend, being at the rate of 10%. The developments continue to give good results, and the seams are becoming wider. The opening of the new colliery is proceeding satisfactorily, shaft-sinking on the incline being in progress.

Witbank Colliery.—This company has worked collieries in the Middelburg district of the Transvaal since 1896. The control was with Neumann's until recently, and is now in the hands of the Central Mining and Investment. The report for the year ended August 31 last shows that 575,196 tons of coal was despatched from the Witbank mine, and 542,484 tons from the Uitspan mine, making a total of 1,012,402 tons. This is a considerable increase over the previous best, 884,071 tons, delivered during the preceding year. The accounts show a profit of £155,952, out of which £14,034 has been expended on capital account, and £17,217 paid as taxes. The shareholders received £113,750, the dividends being at the rate of 32½%.

Cam and Motor Gold.—This company was formed in 1910 to work gold properties in Rhodesia. In 1919 it was reconstructed in order to provide funds for further development and to build a wet-crushing and flotation plant to replace the roasting and cyaniding plant previously employed. Milling was suspended between December, 1918, and December, 1920. The report now issued covers the year ended June 30, 1921. During the period that the mill was running, 58,010 tons of ore was treated for a yield of gold realizing £57,518. This does not represent the actual revenue, for several reasons connected with the starting of a new method of extraction. The costs are given at £98,408, but here again the figures are not really representative of current costs. For these reasons no profit and loss account is given. Since the close of the company's financial year, the operations have been more regular, and from July to November, inclusive, 66,900 tons of ore yielded gold worth £120,617, at a working cost of £99,400. The total reserves are estimated at 600,000 tons, averaging 38s. 2d. per ton at par.

Cape Copper.—This company was formed in 1863 to work copper deposits in Namaqualand, Cape Province, South Africa, and for many years conducted a profitable business. On the possible scale of operations contracting considerably some years ago the company turned its attention to the deposits at Rakha Hills, Chota Nagpur, India. These deposits were developed and smelters and converters erected. War conditions and the low price of copper seriously interfered with work both in Africa and India, and during the last three years heavy losses have been incurred. The report for the year ended August 31 in London and India and April 30 for Africa, shows that the Cape mines have not been producing during the year, but that drilling has been continued, with the result of indicating the existence of further ore supplies. At Rakha Hills 19,941 tons of ore averaging 4·07% was mined and sent to the treatment plant. No figures for the output of copper are given, but the accounts show that £38,416 was received from the sale of ore and metal. The balance of loss for the year in Africa and India was £184,534, following losses of £163,627 and £171,006 for the two previous years. As regards the position at Rakha Hills the directors state that the operations have been affected by difficulties connected with transport, supply of coal, coke, and fluxes, labour troubles, and breakdowns of plant, and that the treatment plant has been operating only intermittently.

Ashanti Goldfields Corporation.—The report of this company now issued covers the year ended June 30, 1921. During this period 62,259 tons of ore was treated, for a yield of 68,817 oz. gold, equal to an extraction of 22·11 dwt. per ton. In addition, 233 oz. was recovered from slags, etc. The par value of the gold was £293,424, and the premium brought an additional £89,744, making the total receipts £383,168. Other income brought the total receipts to £393,154. The working cost was £231,491, development £40,595, royalty £19,158, amounts written off main shaft account and for depreciation of plant £18,519, and reserve for corporation tax £3,500, leaving a net profit of £79,878, out of which £50,000 has been paid as dividend, being at the rate of 20%. The tonnage treated and the profit earned were the lowest for several years, owing chiefly to the scarcity of labour and fuel, and their high cost. Developments have continued to be satisfactory, and the reserve has been maintained, standing on September 30 at 511,400 tons, averaging 22·6 dwt. per ton. It is not intended to sink the main shaft any lower for a year or two, as there is still much productive lateral development to be done. W. R. Feldtmann, the company's consulting engineer, reports that the new plant, in which the ore will be crushed wet, concentrated, and the concentrate roasted and cyanided, has been completed, and will start work this month. Particulars of this plant are given in our Editorial columns.

Taquah Mining and Exploration.—This company has operated gold mines in West Africa since 1888, but the Abosso mine has been worked by a subsidiary since 1901. The report for the year ended June 30 shows that at the Taquah mine 32,451 tons of ore was raised and sent to the mill. This amount compares with 53,844 tons during the previous year, the fall being due to the scarcity of labour. The yield of gold was 19,343 oz., equal to 11·92 dwt. per ton, and the sum realized on its sale was £107,562. The working cost was £85,099, or 52s. 5d. per ton, as compared with 40s. 8d. during the previous year. The allowance for depreciation was £6,757, and £69,694 was written off for diamond-drilling and exploratory work. The net profit for the year was £6,999, which was carried forward. The ore reserve is estimated at 162,433 tons, averaging 51s. 3d. per ton par value, as compared with 182,226 tons averaging 52s. 6d. the year before.

Abosso Gold.—The report of this company (which is a subsidiary of the Taquah Mining and Exploration) for the year ended June 30 last shows that 59,933 tons of ore was sent to the mill, where 23,816 oz. of gold was extracted. The yield per ton was 7·95 dwt., and the gold realized £132,321, or 44s. 1d. per ton. Owing to scarcity of labour, the tonnage treated was only about 70% of that treated the year before. The working cost was £129,816, or 43s. 3d. per ton, and the allowance for depreciation £7,217. The year ended with an adverse balance of £5,386. The amount of development has been considerably restricted. The reserve is estimated at 301,550 tons averaging 34s. 6d. per ton par value, figures almost identical with those of a year ago.

Northern Nigeria (Bauchi) Tin Mines.—This company was formed in 1910 to acquire alluvial tin ground at N'Gel, near the western rim of the Bauchi plateau, Nigeria. The report for the year ended June 30 last shows that 572 tons of tin concentrate was produced, as compared with 465 tons the year before. The largest proportion came from the Gona section, where the output was 309 tons, the remainder coming in about equal amounts from five other areas. The accounts show receipts of £62,759, and an adverse balance for the year of £18,221. This unsatisfactory position is due entirely to the low price of tin. Owing to the necessity of reducing expenditure, little development has been done, but the company has a large reserve of proved ground, estimated to contain 9,551 tons of cassiterite. It will be remembered that a few years ago the company commenced the construction of a hydro-electric installation at Kwall Falls. Unfortunately this installation proved more costly than the original estimate, and its erection had to be suspended for lack of capital. No work has been done since February, 1921.

Naraguta (Nigeria) Tin Mines.—The report of this company covers the year ended March 31, 1921. During this period the output of tin concentrate was 496 tons, as compared with 420 tons the year before. This increase was largely due to improved labour conditions. The fall in the price of tin was such, however, as to far outweigh any advantage accruing from an increased output, and the year ended with an adverse balance of £8,936. The year began with a credit balance of £19,025, and £10,000 has been brought from the reserve to the yearly accounts. A dividend of £8,750 was paid on November 30, 1920, and £8,626 is allowed for income tax. F. O'D. Bourke, the general manager, reports that all the tin properties belonging to the company continue to produce well. He also makes brief reference to the company's interests in the Nigerian gold belt, particulars of which have already been given in our pages.

Sulphide Corporation.—This company operates the Central silver-lead-zinc mine at Broken Hill, lead-smelting works at Cockle Creek, near Newcastle, New South Wales, and zinc-smelting works at Seaton Carew, County Durham. At both Cockle Creek and Seaton Carew other materials than the products of the mine are treated. The report now issued covers the year ended June 30 last. Mining and milling were resumed at the end of November, 1920, after the strike, but the conditions have been very unfavourable owing to high costs of labour and the fall in the price of the metals. The actual profit at the mine and smelting works was only £2,480; indeed, there would have been a loss if it had not been for the profit derived from the acid and super-phosphate production. There were other profits in the trading department and items of income accruing from interest, etc., so that the final balance of profit was £30,008. A dividend at the rate of 5% is being paid on the preference shares, absorbing £30,000. During the period under review, 62,236 tons of ore was raised and sent to the mill, averaging 13·4% lead, 15·3% zinc, and 12·3 oz. silver per ton. There was also treated 12,527 tons of rich dump slime, averaging 19·1% lead, 21·3% zinc, and 16·7 oz. silver. The addition of this slime to the mill feed had an important effect on the revenue, and, in fact, it was largely due to this policy of adding slime that the work could be conducted at all without serious loss. The yield of lead concentrate was 11,833 tons, averaging 63·8% lead, 9·9% zinc, and 44·6 oz. silver per ton, together with 1,738 tons coming from the de-leading of zinc concentrates averaging 59·7% lead, 13·9% zinc, and 37·5 oz. silver. The yield of final zinc concentrate was 21,538 tons, averaging 47·4% zinc, 6·7% lead, and 13·9 oz. silver. At the lead-smelting works, the furnaces treated 49,074 tons of material, consisting of concentrate from the mine, concentrate treated for the Associated Smelters after the Port Pirie fire, purchased ores, and by-products and fluxes. The output of lead bullion was 15,349 tons, which contained 7,631 oz. gold and 1,546,284 oz. silver. At the refinery 15,102 tons of bullion was treated, for a yield of 12,649 tons of soft lead, 35 tons of antimonial lead, 6,189 oz. gold, and 1,298,985 oz. silver. The producer-gas plant made 568 tons of sulphate of ammonia and 50,771 gallons of tar. The latter was treated in the distillation plant, and yielded 22,623 gallons of fuel oil suitable for use in the refinery. The production of sulphuric acid was 21,737 tons, and the production of super-phosphate was 26,991 tons. The demand for these continues to increase steadily. The ore reserve in the mine is estimated at 1,461,783 tons; only a small amount of development was done during the year. As regards the operations at the zinc works at Seaton Carew, three distilling furnaces were at work during the first half of the year under review, and two from January to April, only a very small proportion to the total capacity. The coal strike then put a stop to operations. During the period covered by the report, 3,290 tons of zinc concentrate was roasted, all in hand-operated furnaces. The distilling furnaces treated 3,805 tons of roasted concentrate, for a production of 1,340 tons of spelter, 10 tons of zinc dust, and 33 tons of lead. Owing to a greater proportion of Broken Hill concentrates being treated than during the previous year, the retort residues, 2,824 tons, were better worth concentrating for lead and silver contents, and 1,782 tons, or about half of these residues, on treatment yielded 397 tons of concentrate.

Minerals Separation. — This company was formed in 1903 to work the Sulman-Picard-Ballot flotation process, and has since then continuously expanded its sphere of operations. The report now published gives details of its gradually increasing interests all over the world. The mining industry in Australia continued throughout the year in a condition of depression, which, combined with the strike at Broken Hill, prevented the company from receiving any income from this source in the period under review. The Braden Copper Company in South America treated 2,141,594 tons of ore, comparing with 1,138,058 tons treated in 1919. In spite of the industrial crisis through which Spain has been passing the development of the company's coal business in that country has made progress and the production stage has already been reached. The depression in trade generally in Great Britain, especially in the coal trade, has been accentuated and the progress of the company's coal recovery business has, in consequence, been unavoidably delayed so far as active operations at the collieries are concerned. This delay, however, has enabled the inventors to make further improvements in the processes. In spite of the depression in the iron and steel industry the Skinningrove Iron and Steel Company decided to proceed at once with the erection of the installation of a coal plant, in which all the coal necessary for their requirements of coke will be treated by the company's fine-coal processes. A large installation for the same purpose is in course of erection at the Oughterside Collieries in Cumberland, and is expected to be completed in a few weeks, and the Teams By-Product Coke Company are also adopting the processes. A commercial trial plant with a capacity of 100 tons per day has been erected at Ashington, and is in daily operation, with satisfactory results. This will serve as an exhibition plant for the North of England. The trial plant at Powell Duffryn, erected for the purpose of proving the company's methods for the recovery of fine coal has also been in operation whenever the colliery conditions made it possible, and has been a success from every point of view. The Powell Duffryn Company's experts are satisfied that all the company's claims for their fine-coal recovery methods have now been established. The commercial trial unit with a capacity of 100 tons per day, erected at Nœux les Mines in France has been in operation for some time, and the results have been so satisfactory that it is proposed to increase the capacity to 1,000 tons per day. In connexion with this coal-recovery process, it was important that there should be means of bringing the fine-coal produced into a shape in which it could be readily handled for commercial purposes. Two methods presented themselves for carrying this out: either mixing the fine coal with oil so as to produce a colloidal fuel, or briquetting the fine coal, which, by the methods then known, involved difficulty and too high an expense. The company now reports that the attention since devoted to the question of briquetting has resulted in the discovery of a revolutionary method of treating fine coal in this way, so that the use of colloidal fuel, apart from any question as to its merits in certain cases, has, for the purpose of providing an outlet for the fine coal, been rendered of less importance. The directors have decided not to proceed with the option obtained over certain colloidal fuel patents. Subject to the commercial trial of these briquetting methods now in progress being successful, the company has entered into a long-term agreement with the Powell Duffryn Steam Coal Company, under which briquettes are to be manufactured on a large scale on joint account. Investigations have been made by the company with the object of improving the recovery of nitrate of soda from caliche, and the results obtained have been sufficiently promising for the company to send an expert to Chile to carry out experiments on a commercial scale. The treatment of gold ores by the flotation process has been actively proceeded with this year, and negotiations are already being conducted with some of the leading gold mining groups for the installation of the process on the Rand. The company's accounts for 1920 show an income of £49,605 for royalties, and £29,620 from interest and dividends, while the expenditure on administration, metallurgical investigations, examination of properties, etc., comes to £55,940. The profit was £16,628, which was carried forward.

Kirkland Lake Proprietary (1919).—This company was formed in 1919 as an amalgamation of similar name with the Tough-Oakes Gold Mines Co., the Burnside Gold Mines Co., the Sudbury Syndicate, and the Aladdin Cobalt Co., working properties in the Kirkland Lake gold-mining district, Ontario, with the exception of the last-named, which owned a silver property at Cobalt, Ontario. G. R. Bonnard is chairman, S. C. Thomson is consulting engineer, and W. R. Thomas is manager. The company has subsequently obtained an interest in the Sylvanite property adjoining the Tough-Oakes and Burnside properties on the west. The report now issued covers the period from the formation of the company to June 30 last. This shows that development at the Aladdin mine has not given good results, so work has been stopped for the time. In April of this year the Tough-Oakes and Burnside mines were re-opened and development is proceeding with encouraging results. It is expected that it will be possible to start the mill in April. The financing of these operations has been done by means of loans. In September and October, W. H. Goodchild made a geological examination of the company's properties, and a brief report by him is attached to the director's report. We give his views herewith: "I am very favourably impressed with the prospects of the company's properties in the Kirkland Lake district, and the following epitomizes my more important conclusions. (1) The central gold-bearing fracture zone of the Kirkland Lake district traverses the Burnside and Tough-Oakes ground from end to end giving a length along the strike in these leases of about 4,000 ft. It is practically intact from end to end. There are good prospects of other ore-bodies being found in certain sections of this zone, one rich body being definitely located on it during the course of my visit. Ore is likely to persist to great depths in this fracture zone in places where the collateral structure of the country is favourable. (2) There is some evidence for the existence of another similar fracture zone of correct age coursing through favourable porphyry country in the far southern portion of the Burnside ground. It is important to note that the larger porphyry masses in the Kirkland Lake area are remarkably consistent ore-forming rocks where they are traversed by strong fracture zones of appropriate age. There are great possibilities for this southern unexplored area. (3) The outlook for No. 2 vein is poor, but this is compensated for by the depth prospects in the main gold fault, which is the fault that cut off this vein in the bottom of the Tough-Oakes mine. (4) No. 11 vein is opening up well in depth and there are some prospects of other similar veins being found in the vicinity. (5) The northern group of veins on the Tough-Oakes leases are practically exhausted in their upper horizons and appear to have no serious prospect in depth. (6) The prospects for the Sylvanite property are of the very best quality. The main central gold fault courses through this property from end to end in favourable porphyry country for the full length along the strike amounting to about 1,400 ft. There are other important mineralized fractures coursing through this same favourable country. (7) A small section of the Aladdin Cobalt property lying between the Nipissing and La Rose leases may still be ranked as first-class silver-prospecting ground as this is understood in the Cobalt field."

Camp Bird.—This company was formed in 1900 to work the Camp Bird gold mine in Colorado, and for a series of years very handsome profits were made. The company then promoted the Santa Gertrudis Co., to work a silver mine at Pachuca, Mexico, and has more recently taken financial interests in the Mexican Corporation, the National Mining Corporation, and other companies. For the last few years operations in Colorado have been restricted to exploring ground some hundred feet below the lowest level in the old mine, the attack being made by means of a tunnel driven from the valley below. The results of this exploration have been mixed, and though valuable ore was found in places there was not sufficient of it to warrant it extraction. The directors therefore gave instructions that the work should cease in November, 1920. The report now issued covers the year ended June 30, 1921. This contains an account of the exploratory work written by W. J. Cox, the general manager, who records his opinion that results warranted further exploration, and his regret that operations should cease. As the company had no income either from output or from dividends in other companies, the accounts consist merely of the items of development expenditure and administration expenses, and the year ended with an adverse balance of £16,988. Particulars of the Santa Gertrudis and Mexican Corporation are given elsewhere.

Santa Gertrudis.—This company operates silver mines at Pachuca, Mexico, and is controlled by the Camp Bird, particulars of which are given in the preceding paragraph. The report for the year, ended June 30, 1921, shows that the mill treated 200,847 tons of ore from the Santa Gertrudis mine and 274,873 tons from the El Bordo group. The yield was 4,533,338 oz. silver and 21,680 oz. gold. No profit has been made as the price of silver fell seriously and unexpectedly. Little or no new ore was disclosed at Santa Gertrudis, and the reserve on June 30 was estimated at 309,911 tons. At the El Bordo group development continues to give satisfactory results, and much more work remains to be done that will open up large bodies of ore. The reserves are estimated as follows: El Bordo 1,064,059 tons, El Cristo 121,797 tons, and Malinche 133,761 tons, the average content per ton over the three mines being 11 oz. silver and 1 dwt. gold. The daily capacity of the mill is being increased from 1,500 to 2,000 tons, but owing to shortage of hydro-electric power the work of extension has been hindered.

British Platinum and Gold Corporation.—This company was formed in 1918 to acquire alluvial deposits in the Choco district on the west side of Colombia. Inder, Henderson, and Dixon are the consulting engineers. The first dredge was built to treat the Opogodo flats, and started work on January 15, 1921. The second, for the Condoto River property, has been shipped, and should be ready to commence operations in February, 1922. The report now issued covers the year ended July 31 last. During the 6½ months the Opogodo dredge was at work, it treated 177,000 cu. yd. of ground, and recovered 1,516 oz. of platinum and 446 oz. of gold. The proceeds of the sales of the metals were £26,723, so that the yield per yard was 36·3 pence, while the field cost was 9·97 pence.

The profit and loss account shows a profit of £17,859. The company also has an interest in the Colombian Proprietary Gold Mines, Ltd., floated in 1921, to work ground south of Buenaventura. The dredge for this ground is now in course of shipment from this country, and is expected to start work in July, 1922.

Frontino and Bolivia Gold.—This company has worked gold mines in Colombia since 1864, and was reconstructed in 1886 and 1891. Pellew-Harvey & Co. are the consulting engineers, and J. Reed is manager. The report for the year ended June 30 last shows that 29,420 tons of ore was mined and sent to the mill. The production of gold by amalgamation was 17,234 oz.; 729 tons of concentrate yielded 646 oz.; 15,610 tons of sand yielded 2,692 oz.; and 12,557 tons of slime yielded 1,311 oz. The total yield was 21,910 oz., equal to 14·89 dwt. per ton. The revenue was £104,721, and the net profit £16,919, while £16,780 was brought forward from the previous year. Debenture interest absorbed £4,513, and preference dividend £2,339, while £3,500 was distributed as ordinary dividend, being at the rate of 2½%. Since the close of the company's year £6,004 debentures have been paid off, and other requirements include payment for shares in the Marmajito Mines, Ltd. Development during the year has given uneven results, and the reserve stands at 53,200 tons, averaging 16 dwt. per ton, as compared with 65,600 tons of similar tenor the year before. At the Marmajito mine pumping was commenced on June 6, 1921, and the water was all removed by September 16. The compressor was started on October 26, and development is now steadily in hand.

Tolima.—This company has worked the Frias silver mine in Colombia since 1871. Operations were highly profitable in the early days, but reconstructions were necessary in 1903 and 1909, while stoppages occurred during the war, owing to the impossibility of selling the concentrate. At the present time operations are suspended, on account of the low price of silver. The report for the year ended June 30 last shows that during the first ten months, until the stoppage on April 20, 5,732 tons of ore was raised and treated for a yield of 605 tons of shipping concentrate, averaging 467 oz. of silver per ton and 11·3% of lead. It is estimated that the developed ore will yield 1,520 tons of shipping concentrate. The accounts show a loss of £14,166. The future of the company causes some anxiety, for there are no available funds left, and debentures for £17,780 have to be satisfied. The directors are now considering schemes for raising additional capital.

Berenguela Tin Mines. — This company has worked tin mines in Bolivia since 1905. The report for the year ended June 30 last shows that 329 tons of tin concentrate was produced, as compared with 386 tons the year before. Owing to the increased costs and to the fall in the price of tin there was a loss of £10,975. The year began with a credit balance of £8,482, and ends with an adverse balance of £2,493. The company has a substantial claim against the Inland Revenue for the return of excess profits duty for the previous year.

Malayan Tin Dredging. — This company has worked alluvial tin ground in the Kinta Valley, Perak, since 1911. Four dredges are at work, and two more are on order, of which one is now in course of erection. The report for the year ended June 30, 1921, shows that all four dredges were in fairly steady commission, and that they extracted 939 tons of tin concentrate from 3,258,200 cu. yd. of ground. These figures compare with 2,558,500 cu. yd. and 594 tons during the previous year. The increase in the output was partly due to the more regular running of the dredges, and partly to the increase in the yield per yard from 0·52 lb. to 0·64 lb. The credits for the concentrate were £120,934, and other items of revenue brought the total to £129,798. The net profit for the year was £20,692, out of which £18,000 has been distributed as dividends, being at the rate of 10%.

Anglo-Persian Oil.—This company was formed in 1909 by the Burmah Oil Company to develop oil lands in Persia. During the war the British Government provided working capital, and now holds a large proportion of the ordinary shares. The report for the year ended March 31, 1921, now issued, does not give particulars of output or of income. The gross trading profit was £4,948,627, and after the payment of debenture interest, taxes, and royalties, and placing £685,000 to various reserves, the net profit was £2,352,814. The preference shareholders received £400,000, and the ordinary shareholders £1,215,000. Though the company does not give particulars of output, it is of interest to note that the chairman mentioned in his speech to shareholders that their F. 7 well, "from which the company has been getting its main production for a number of years," has yielded 4,000,000 tons during the past ten years, and is now giving a daily yield of 2,000 tons. During the year under review test wells have proved additional oil-bearing territory. The oilfields have been electrified throughout, and the cost of operations will be greatly reduced. A dispute has arisen with regard to certain concessions in Northern Persia, for the Persian Government has been attempting to grant concessions to other parties, which have already been granted to the company, and the present position with regard to this incident is not quite clear. Exploration in other countries continues to be conducted by the subsidiary, the D'Arcy Exploration Co., and, in particular, interests have been acquired in the Argentine and Egypt. The refinery at Llandarcy, near Swansea, is nearly completed. Operations were started on a limited scale in July last, and the works will be at full capacity in the spring. The results obtained here are so satisfactory that arrangements are being made to build refineries in other consuming centres. In March last additional capital was raised for the expansion of the business, and a further issue is in contemplation.

Trinidad Leaseholds.—This company was formed in 1913 by the Central Mining & Investment Corporation to work oil lands in Trinidad and to erect a refinery. The report for the year ended June 30 last shows that 158,046 tons of crude oil was produced, as compared with 177,709 the year before, while 33,803 tons was purchased from other companies. The refinery treated 176,642 tons as compared with 141,126 tons. The profit for the year was £158,483, but owing to financial requirements in connexion with stores and additional equipment no dividend is being distributed at present. The capacity of the refinery has been increased to 800 tons per day, and will be still further increased to 1,000 tons. A Greenstreet cracking plant is approaching completion.

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EDITORIAL

WHILE most of the proposals of the Decimal Association are acceptable to would-be reformers of the British system of weights and measures, it must be said that the suggestion to call a "litre" a "metric gallon" will only subject the Association to the ridicule of its enemies. As the Imperial gallon occupies 277 cubic inches and the United States gallon (the old English gallon, by the way) 231 inches, while the litre is equivalent to only 60 inches, it is obvious that a litre can by no effort of the imagination be likened to a gallon. If, on the other hand, the proposal was to make half a dekalitre the standard international, or metric, gallon, the Decimal Association would receive general support.

ANOTHER article on the mineral resources of India appears in this issue. In this article Mr. Cyril Fox discusses the bauxite deposits and the possibility of using them as foundations for new industries. Mr. Fox is a member of the Indian Geological Survey, and has recently succeeded Dr. Coggin Brown at the office of the Indian Trade Commission in London. In other articles to follow he will deal with certain problems connected with coal and bituminous substances. In publishing these articles on Indian mineral deposits, we have it in view to remind the public and the Governments of the immense value of our Indian Empire, and to arouse some protest at the manner in which British prestige in that great country is being frittered away by unapt politicians.

THE final figures for the output of metals and minerals in the United Kingdom during 1920 were published just thirteen months after the termination of the year, thus following the custom of the past few years. Moreover, the modern system of omitting mention of individual mines is still adopted, and the only detailed figures are by counties. The lateness of publication and the method of presenting the returns detract from the interest of the report, but one or two items may be quoted. The tin concentrates produced during the year amounted to 4,857 tons, from which 3,065 tons of metallic tin was obtainable by smelting, as compared with 5,156 tons and 3,271 tons respectively during 1919. The output of tungsten concentrate was 94 tons, calculated to contain 52% metal. The amount of zinc concentrate produced totalled 5,064 tons, from which 1,655 tons of metal was obtainable, as compared with 6,933 tons and 2,436 tons; while the amount of lead concentrate was 15,399 tons calculated to yield 10,961 tons of metal, as against 13,868 tons and 10,277 tons.

LAST month reference was made in this column to the alleged discovery by a German chemist of a method of making "synthetic" gold in sufficient quantities to enable his country to liquidate the reparation debt. We are now informed that there is also a hope of paying this debt by extracting gold from sea-water. Anyway, there is a certain amount of subdued excitement in German scientific circles with regard to improvements in the Bauer process for precipitating the gold on charcoal. This process was tried two or three years ago, but without success, owing to the other salts in the sea interfering with the action. It is stated that these difficulties have been overcome, and that high hopes are consequently prevalent of a resuscitation of the purchasing power of Germany. Reverting to the "synthetic" gold, we note that Professor Sir Ernest Rutherford is to lecture before the Institute of Metals in May on the possible transmutation of metals. He may be expected to give an authoritative statement on the present scientific aspect of this subject.

IN the discussion on Dr. Morrow Campbell's paper, read before the Institution of Mining and Metallurgy, rather over a year ago, Professor H. C. H. Carpenter told mining engineers many new things about the formation of crystals under heat and strain. The fact that crystals can be formed in this way while the material is still in the solid phase provides geologists with an additional means of attacking many problems relating to the genesis of crystalline minerals and ores, but it is of far greater immediate value to the metallographist. During the past year Professor Carpenter has continued his researches, and has by the method mentioned succeeded in forming crystals of aluminium several inches long, large enough for use in the machines for testing tensile strength and elongation. He is thus able to determine these physical constants for the true metal, as distinguished from those of rolled or cast metal, and to obtain fixed figures to which the characteristics of the commercial forms may be referred. The results given in his paper read in November before the Royal Society are therefore of fundamental importance in metallography. Professor Carpenter indicates in his paper that experiments in this direction are being made with other metals besides aluminium.

THE alarming increase of murders, suicides, and accidental deaths arising from poisoning by the carbonic oxide contained in household gas gives us a regrettable opportunity of using that discredited tag: "I told you so." In June and September last we recorded our protest against the Gas Regulation Act of 1920, which allowed the gas companies to use unlimited amounts of water-gas in their town supplies. During the past month or so Dr. W. A. Bone has voiced a similar protest in *Nature* and the *Times*, and he has been backed by other fuel experts, of whom Mr. David Brownlie may be mentioned. Furthermore, Dr. J. S. Haldane, one of the referees under the Act, has written to the *Times* to say that, though he holds this position, he has no authority in the matter of carbonic-oxide content, and that as a matter of fact he considers the present regulations quite unsuitable. In the newspaper controversy the only scientist to back the regulations is Dr. Charles Carpenter, and his argument was to the effect that the use of water gas for domestic purposes is no more dangerous than smoking a Havana cigar; but then Dr. Carpenter is the chairman of one of the big gas companies. His logic is on a par with that of the theatre manager who did not see why people should object to the use of swear words on the stage, because the children would be sure to learn them somewhere else, anyway. It is clear that something must be done without delay. Our suggestion is that Dr. Haldane should exert his great influence in some unofficial way to bring about the retirement of these regulations or their very severe modification.

Imports and Exports in 1921

Some idea of the depressed condition of the trade of the country in metals and minerals can be obtained from the returns relating to the imports and exports issued by the Board of Trade. No doubt those who follow the brief monthly statistics published in our pages will be aware of the position, but a general survey of the year's figures will be of interest. In the first place it is worthy of record that during the coal strike 3,433,568 tons of coal was imported from abroad, costing at the port of entry £12,129,951. Then the import of iron ores was 1,887,574 tons, as compared with 6,499,551 tons in 1920, and 7,442,249 tons in 1913; and whereas the imports in 1921 cost £3,736,082, those in 1913 cost £7,045,883, so that the cost per ton was double what it was eight years ago. The imports of pyrites were 288,440 tons, as compared with 630,564 tons in 1920, and 781,711 tons in 1913, and the imports of copper ore, matte, and precipitate were 30,833 tons, as compared with 31,164 tons in 1920, and 133,375 tons in 1913. The imports of tin concentrate were 21,588 tons, as compared with 33,810 tons in 1920, and 34,592 in 1913. Coming now to the imports of refined metal we find that the imports of copper were 84,320 tons, as compared with 104,428 tons in 1920 and 104,678 tons in 1913; lead 132,602 tons as compared with 162,848 tons in 1920 and 204,136 tons in 1913; tin 20,967 tons as compared with 28,749 tons in 1920, and 45,682 tons in 1913; and spelter 72,486 tons as compared with 109,368 tons in 1920, and 145,004 tons in 1913. The figures for the exports tell a similar tale. The exports of coal were 24,660,552 tons in 1921, as compared with 73,400,118 tons in 1913; and the coal used in steamers engaged in the foreign trade was 10,926,444 tons in 1921, as compared with 21,023,693 tons in 1913. The total exports of iron and steel were 1,700,407 tons in 1921, as compared with 3,251,225 tons in 1920, and 4,969,224 tons in 1913.

The Government has resumed the issue of figures for the imports and exports of gold and silver. From these we give a few extracts herewith. During 1921 the amount of unrefined gold had a par value of £38,021,165, of which £34,513,606 represented the Transvaal product, while £2,064,016 came from Rhodesia, and £1,083,727 from West Africa. The amount from the Transvaal will henceforth gradually diminish, as the local mint has just commenced operations. The import of refined gold was worth £6,154,084, of which £5,701,463 came from India. The exports of refined gold were £56,270,494, of which £53,083,107 went to the United States. As regards silver, the imports of unrefined bullion were 5,787,244 oz., and of refined silver 40,245,164 oz. Of the refined silver, 16,844,281 oz. came from the United States, and 5,235,113 oz. from Canada, and large amounts of silver, refined and unrefined, came from Holland, Belgium, and France, arising no doubt from coinage melted down. The exports of refined silver totalled 62,562,944 oz., of which 38,721,561 oz. went to India and 19,685,334 oz. went to China. These figures indicate the nature of the flow of the precious metals to and from London. The gold that comes here goes to America to help to pay debts and to straighten the trade balance; the silver comes from the American mines and goes to those apparently bottomless sinks, India and China.

Origin of Pyritic Ore-Bodies

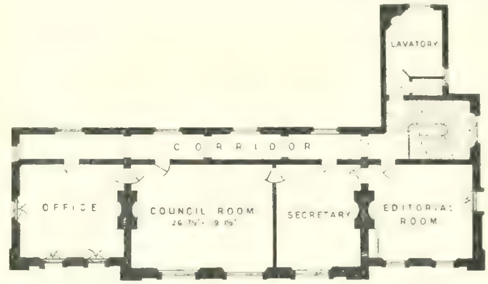
The origin of the large bodies of pyrites in the south of Spain and elsewhere once more formed the subject of discussion at a meeting of the Institution of Mining and Metallurgy, when a paper was read last month by Mr. John F. Allan on the Sulitjelma mines in the north of Norway. Mr. Allan directed notice to these deposits as he holds them to be typical examples of magmatic injection, arguing that, though the Spanish deposits may be taken to be replacements and infiltrations by magmatic or other waters, there can hardly be any doubt that the Sulitjelma ores accompanied the intrusive eruptive. His personal examination of these deposits convinced him that Beyschlag, Krusch, and Vogt were absolutely right in including them under the title "intrusive pyrite deposits," though the correctness of their inclusion of the Spanish deposits under the same heading is now open to considerable doubt. Such, however, has been the change of opinion of recent views among geologists and mining men, that Mr. Allan obtained no support from the speakers at the meeting, except perhaps from Professor Truscott, who stated the pros and cons with judicial impartiality. The chief speaker was Sir Thomas Holland, who naturally received a warm welcome on his return to geological debate. Sir Thomas argued that the massive ores in the slate did not come along with the gabbro intrusion, though probably this was the case with the chalcopyrite and pyrrhotite ores in the footwall of the gabbro, and that the massive ores were formed on a subsequent occasion, presumably after other earth movements with which water was associated Mr. Thomas Crook and Dr. J. W. Evans took much the same lines. Dr. Evans's remark that the massive ore was deposited from waters which might "or might not" have come from below seems to indicate a tendency among geologists to rely once more on meteoric waters as well as waters of magmatic origin.

In all these discussions about the origin of ore deposits most of us are at the disadvantage of having no personal knowledge of the particular deposits in question. Another obvious drawback is that the actual observers will necessarily have varying judgments as to the relative value of the evidence obtainable, and will indeed often not recognize the value as evidence of certain things that they see. Some observers, too, are inclined to limit the scope of their inquiry, being, as it were, overwhelmed by the evidence available, and thus confine their arguments and investigations to one particular aspect of the theory of ore deposits. It may happen that a reader of the paper may want certain evidence for the purpose of checking an idea, and that this information may not have appeared of importance to the writer of the paper. Thus the arguments and speeches may often be at cross purposes. To take a case in point. The gabbro at Sulitjelma is said to have brought all the sulphides with it, and also to have been subsequently changed to chlorite schist, after cooling, by the agency of intense heat and pressure. Also the sedimentaries show the results of the violence of some action of this sort. The question arises as to whether the massive sulphides bear similar trace of such action. It can hardly be possible for such unstable compounds to remain unaffected by heat and contortion.

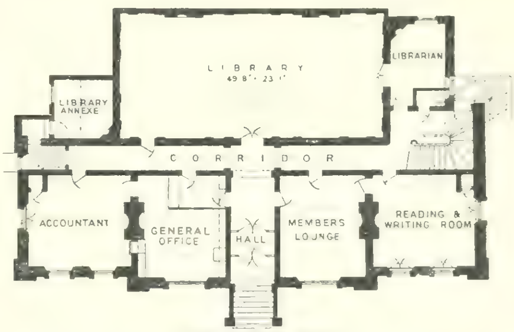
The discussions at the recent meetings of the Institution tend to show an inclination on the part of many men to revert partially to the downward infiltration theory and to take the magmatic water theory as less than a universal rule. Moreover, fewer deposits are now attributed to the flow of magmatic sulphides. At eras of change of opinion such as the present, it is well to delve into the history of economic geology once more, and to refresh our memories with regard to the opinions of the earlier writers, for with the accumulation of evidence since their days some mutual service between theories may arise.

The Institutions' New Home

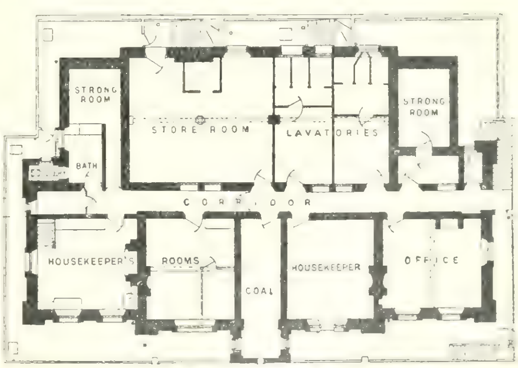
The removal of the Institution of Mining and Metallurgy and the Institution of Mining Engineers to their new home at Cleveland House, 225, City Road, has been completed, and everything is now in efficient working order. In May last we gave particulars of the reasons why it became necessary for the Institution of Mining and Metallurgy to move from Finsbury Circus and of the mutual arrangement made between this institution and the Institution of Mining Engineers. On the same occasion we voiced the regret of most mining men that circumstances compelled the migration of the institutions to an inconvenient and not altogether desirable neighbourhood. In August we published a photographic view of the exterior of the building. Now that all internal arrangements have been completed we are able to give plans of the various floors, with indications of the uses to which the rooms are put. Before describing the accommodation in detail we would remark prefatorially that the building has been furnished and decorated comfortably, and with excellent taste, and that, when once inside, members are in no way annoyed by the rather unpleasant surroundings, the only noticeable drawback perhaps being the noise of the heavy traffic in the roadway. It will be seen from the drawings that the house consists of three floors. The main entrance from the street is on the upper ground floor. To the left of the entrance hall is the general inquiry office, with a room behind for the accountants. To the right are two rooms, the first fitted as smoking lounge, while the second contains the current newspapers and technical journals. Directly in front of the entrance hall is the library, which is the handsomest room in the house, measuring 50 ft. by 23 ft., and being lit from the roof. The war memorials, which were described in our December issue, are in the library, that of the Institution of Mining and Metallurgy in the centre of the floor, and that of the Institution of Mining Engineers fixed to the wall at the left-hand end of the room. At the right-hand end is a den for the librarian, Mr. F. O. Leaning, who we regret to say is at present kept at home by serious illness. On the first floor we come at the top of the staircase to the editorial room, where Messrs. G. F. Bird and Percy Strzelecki are to be found. Next is the room of the secretary of the two institutions, Mr. Charles McDermid. Further along the corridor is the council room, and at the end is the office of the stenographers and typists. In the basement are the housekeeper's rooms, store-rooms for the institutions' publications, etc., and an extra office for the use of the Institution of Mining Engineers. An idea of the floor area of the building can be gained by reference to the dimensions of the library, while the loftiness of the rooms can be gauged by an inspection of the photograph published in August. The accommodation is ample and the allotment of the rooms is ideally convenient. Those who have been responsible for the arrangements are to be congratulated on the excellent results.



FIRST FLOOR



UPPER GROUND FLOOR



LOWER GROUND FLOOR

REVIEW OF MINING

Introduction.—The mining position is not so good as it was a month ago, for the signs of a revival then visible have largely disappeared since, and the prices of metals, including gold, have sagged again. The labour strife on the Rand is still serious. In the United States many of the copper mines are about to reopen or have reopened; this fact, together with the restricted world demand, means a continuation of low prices.

Transvaal.—The Rand mines have been idle for a month and the industrial position is still obscure. The cable messages printed in the London papers have been contradictory as regards both fact and prophecy, it being alternately stated that the majority of the white workers are desirous of going back and of disowning the extremists among the leaders, and that there is to be an armed revolution throughout the country. It is generally believed, however, that the mines will start again before long.

The fall in the gold premium comes as a reinforcement of the Chamber of Mines' argument that costs must be cut down. This fall, combined with the suspension of operations, is hurrying the crisis at many of the low-grade mines, and it is certain that a number will permanently close, while at others the output will be reduced. Already Roodepoort United, New Goch, and Luipaard's Vlei are announced as at an end.

The directors of the Bantjes Company have given up hope of finding any more payable ore on the 11th level driven from the adjoining Consolidated Main Reef mine, as the exploratory work has been continuously disappointing. This was the only ground that held out any hopes, so it has become necessary to cease operations entirely, and the company is to be liquidated.

The Sheba company, operating in the Lydenburg district, is to be reconstructed once more, with the object of providing further capital for development and for discharging loans. It will be remembered that milling was suspended early in 1918 owing to the exhaustion of reserves and unpropitious conditions. Since then development has proceeded, and the prospects now at the Zwarzkopje and Intombi sections are quite good. In the reconstruction shareholders are entitled to subscribe for eleven new shares of 5s. each credited with 2s. 6d. paid, in exchange for ten 5s. shares in the present company. Of the new shares 800,000 are underwritten, so the company is sure of obtaining £100,000 new capital.

Cape Province.—A strange prospectus is being advertised and circulated offering shares in the Orange River Asbestos Mines, Ltd. The property adjoins that of the Cape Asbestos Company, and is stated to contain over half a million tons of asbestos of the crocidolite variety. The directors consider an output of 100 tons per week as "a very conservative basis" for estimates, and figure on making a profit of £36,400 per year with this output. But one of the directors, whose firm is also secretary to the company, is the secretary of the Direct Fish Supplies Co., Ltd., a company which is in trouble with the Somerset House authorities for not producing a statement of account. So the Orange River Asbestos Mines, Ltd., can hardly be taken seriously. Moreover, the directors have registered it in the Isle of Man, a proceeding which does not commend itself to business men.

Rhodesia.—The output of gold during December was 55,968 oz., as compared with 53,098 oz. in November and 46,190 oz. in December, 1920. The total during 1921 was 591,525 oz., as against 552,498 oz. in 1920. The other outputs during December were: Silver 13,370 oz., coal 50,457 tons, copper 270 tons, asbestos 755 tons, arsenic 42 tons, mica 2 tons, tin concentrate 1 ton, diamonds 6 carats. The following table gives the outputs during the year 1921, and also those of 1920:—

		1920	1921
Gold	Oz.	552,498	585,525
Silver	,,	158,982	152,989
Copper	Tons	3,108	3,079
Chrome Ore	,,	60,269	50,188
Asbestos	,,	18,823	19,529
Coal	,,	578,492	574,753
Tungsten Ores	,,	17	17
Arsenic	,,	437	361
Antimony	,,	11	—
Mica	,,	97	85
Tin	,,	4	5
Diamonds	Carats	243	177

Two months ago Mr. Stanley Edwards secured control of the Gaika Gold Mining Company, one of the Gold Fields Rhodesian Development group, and appointed a new board. It is now announced that Mr. A. M. Mackilligin is to go to Rhodesia to investigate the mining position, more particularly with a view to pressing development. The directors propose to put a large part of the surplus funds of the company into Rand shares, and have bought New

Modders, Gedulds, Brakpans, Springs, and Union Corporations.

West Africa.—It will be remembered that the property of the Taquah Central Mines, Ltd., was reopened in June, 1920, funds having been provided by the Taquah Mining and Exploration Co. Unfortunately the lode in the eastern section of the mine, where work was restarted, has proved to be rather poor, and a subsequent bore-hole cutting the lode 200 ft. deeper has given equally discouraging results. A second bore is now being sunk to test the western section of the property. Prospecting has been commenced on the north and south sections, and the surface indications in the latter are distinctly hopeful.

Nigeria.—A promising deposit of rock phosphate has been discovered by members of the Geological Survey at a point about 30 miles north of Lagos. Samples return from 20 to over 60% calcium phosphate. The place is easily accessible, and investigations as to the extent and average composition are to be taken in hand shortly. Probably the material will prove of value in fertilizing the sandy northern regions of Nigeria, and eventually it may also find an outlet for export.

Australia.—The yearly report of the Mount Lyell Company, extracts from which are given elsewhere, is of particular interest at present, seeing that this is one of the few Australian mining companies that has been able to keep going. We are able to supplement the information given in the report with some figures of costs prepared as evidence before the Commonwealth Arbitration Court when the wages question was being considered last June. For the six months ended March 31, 1921, the cost of producing a ton of blister copper (the total being 2,644 tons obtained from 102,585 tons of ore) was £104 11s. 6d., the individual items being: Mining, £39 7s. 11d.; concentrating and sintering, £7 1s. 5d.; smelting £30 0s. 10d.; converting, £3 8s. 7d.; administration, £3 4s. 5d.; refining and realization, £14 11s. 1d.; and depreciation, £4 14s. 5d. From this cost was deducted £10 1s. 6d., the value of the gold and silver contents, bringing the net cost per ton of blister to £94 10s., and of electrolytic to £95 6s. 2d. Of the £104 11s. 6d., £63 9s. 4d. went in salaries and wages, £17 9s. 1d. in stores, and £23 3s. 1d. in other expenses. Since these figures were prepared rearrangements of underground work and the introduction of mechanical handling and other improvements above ground have brought down the costs, and ore of higher average grade has been extracted. Thus the company can still carry on, though no divisible profit is being made.

A company called the Hohonu Gold Sluicing Co. has been formed more or less under the auspices of the Waihi Grand Junction Co. to work alluvial gold properties at Hohonu, in the Grey district of New Zealand, not far from Reefton. Mr. A. H. Richards reports that the sluicing operations have yielded gold at the rate of 2d. per yard, and that the cost should be less than 1d. The expenditure necessary for bringing the scale of operations to 4,800 cu. yd. per week is estimated at £12,350. This is probably the lowest grade alluvial being treated at present and the margin of profit will be very small.

India.—The Bengal Iron Company, whose activities Dr. Coggin Brown described in our issue of July last, has issued £600,000 debentures to provide funds for extensions in various directions. New blast-furnaces have been erected, and developments at the iron and coal mines are being extended. The furnaces are at Kulti, 142 miles west of Calcutta, and the chief iron ore mines are at Manharpur in the Kolhan Estate of Singhbhum, while the coal mines are in the Raniganj and Jherria districts.

Burma.—At the meeting of the British Burmah Petroleum Company held last month the chairman gave some account of the rebuilding of the refinery and of the new drilling campaigns. Recognizing that their properties of Yenangyaung have seen their best days, the directors are taking in hand the development of another property in the district, 30 miles from the Irrawady. They have also secured oil rights over 58 square miles in the North-West Provinces and the Punjab. Through the affiliated company, the British Sinai Petroleum Co., work is being done in Egypt and the Sinai Peninsula, though the results obtained so far are not of great importance. Another affiliated company, the Eastern Petroleum and Finance Co., has extensive options in the Comodoro Rivadavia oilfield in the Argentine Republic. Messrs. John Taylor & Sons are the managers of this group, and Messrs. A. Beeby Thompson & Partners are the consulting engineers.

At the adjourned first annual meeting of the Burma Corporation, which was formed under local laws two years ago, the Chairman took the opportunity of reviewing the present position of the company, and of the metallurgical and commercial problems involved. As we quoted at some length from the directors' report in our December issue, it is not necessary to refer to the matter further on this occasion. A lengthy report of the chairman's speech is given elsewhere in this issue.

Canada.—The long-expected deal whereby the Guggenheims, otherwise the American Smelting and Refining Co., purchase a block of shares in the B.C. Silver Mines is now announced as an accomplished fact. Mr. C. A. Banks acquired control of this company some time ago, for the Selukwe Gold Mining Company. As the Guggenheims have the control of the Premier mine it was expected that they would also want to work the properties adjoining belonging to the B.C. Silver Mines. The present deal should be of great prospective advantage to the Selukwe company.

The liquidation of the Tyee Copper Co., which used to operate copper mines and a smelter on Vancouver Island, is about complete, and a sum of £45,000 is to be distributed among shareholders. The mine was worked until 1907, and from that year until the end of 1911 the smelter treated custom ores. In 1916 the smelter and other assets were handed over to an American syndicate, the payments to be spread over five years. The last payment has recently been made, so the company is now to go out of existence.

United States.—The output of petroleum during 1921 is reported at 469,639,000 barrels, valued at $753,300,000. This is the highest output on record, comparing with 469,639,000 barrels in 1920. The home consumption was 525,407,000 barrels, as compared with 530,474,000 barrels. The United States petroleum authorities estimate the world's output at 750,000,000 barrels, as against 695,000,000 in 1920.

The output of refined lead in the United States from home ores during 1921 is estimated at 390,000 tons, as compared with 476,849 tons in 1920. In addition 50,000 tons was produced from imported ores, as compared with 52,808 tons. The production of zinc from home ores during 1921 was 194,000 tons, and from foreign ores 2,500 tons, as compared with 450,045 tons and 13,332 tons respectively in 1920.

Mexico.—In the Mining Digest this month particulars are given of the successful use of the Sullivan diamond-drill in prospecting for oil at depth on one of the properties in the Tampico oilfield. It has always been a mystery why the diamond-drill has not been used for this purpose before, instead of the expensive equipments hitherto employed for testing likely ground. For instance, the Derbyshire borings could probably have been done for a fraction of the actual cost.

The exports of oil from Mexico during the year 1921 are reported at 191,418,000 barrels, as compared with 156,432,000 barrels during 1920.

Chile.—The Poderosa Mining Company, which has worked copper mines at Collahuasi, in Chile, since 1908, is purchasing the property and plant belonging to the Société Francaise des Mines de Cuivre Collahuasi la Grande, in the same district. This French company is in liquidation, and the mines have not been worked for some years. There are no reserves of ore, but it is believed that the prospects are good. The directors of the Poderosa consider the present a favourable opportunity for writing down the capital, so each £5 share is to be converted to two shares of £1 each and the total from £500,000 to £200,000. For the purchase of the new property, 200,000 new shares of £1 each are to be created and issued to the liquidators of the French company.

Persia.—As announced in the directors' report issued last month, the Anglo-Persian Oil Company decided to issue further capital for expansion in many directions, particularly the testing of new properties in Persia and elsewhere, the extension of present and the building of new refineries, and the completion of distributing arrangements. The issue has since been made, and consists of 2,000,000 8% cumulative first preference shares of £1 each, offered at £1 1s., and 600,000 ordinary shares of £1 each offered at £3 5s. This issue of capital is of special note, as hitherto the ordinary shares have not been offered publicly; in fact, nearly all have been held by the British Government. The shares now offered proved highly attractive to investors.

Portugal.—The proposed sale of the San Domingos pyrites properties of Mason and Barry, mentioned in our issue of October, is not to take effect.

Roumania.—The output of crude oil during 1921 was 1,160,900 tons, as compared with 1,034,000 tons in 1920.

MODERN MINE FANS

By DAVID PENMAN, B.Sc., M.Inst.M.E.

Principal of Dhanbad School of Mines and Geology, India

Introduction.—In order to maintain the atmosphere of large collieries and mines in a satisfactory state of purity and coolness it is necessary to circulate very large quantities of air. Not infrequently the quantity in circulation may approximate to half-a-million cubic feet per minute. The volume of air necessary for adequate ventilation depends upon a variety of conditions, chief among which are: (*a*) the depth, (*b*) the extent of the workings, (*c*) the number of workmen employed at one time underground, (*d*) the nature and amount of the gases given off from the strata, (*e*) the amount of explosives used, and (*f*) the climatic conditions of the district in which the mine is situated. In this country, in South Africa, and on the Continent, the law requires a certain standard of atmospheric purity to be maintained in all places where men have to work or travel. In view of those enactments and from the higher consideration that the working efficiency of the miner is closely bound up with the physiological state of the atmosphere, it is essential that sufficient air be kept in circulation not only to dilute and render harmless the noxious gases, but to keep the atmosphere cool and dry. Only in small and shallow mines, and in particular those which communicate with the surface at several points, is ventilation by natural means competent to provide the necessary air circulation, and even in such cases there may be periods when the current is practically at a standstill. In the vast majority of coal mines and in the deeper and more important metal mines in all countries it is necessary to employ mechanical ventilation so as to ensure at all times an adequate flow of fresh air in the underground workings. By far the most convenient and most economical means of providing such an air current is found in the centrifugal fan, which has now reached a high stage of efficiency.

Principle of the Centrifugal Fan.—In studying the principle underlying the operation of the centrifugal ventilator, the problem may be considered from two points of view. First consider the centrifugal principle. All bodies when revolved in a circular path are acted upon by a force which tends to cause them to travel from the centre outwards. Air is no exception to this law, and so if air is confined in a fan or wheel having a number of blades or vanes fixed between two parallel discs (see Fig. 1), and being open only at the centre and the circumference, it will travel from the centre towards the circumference as the wheel revolves, as indicated by the straight line in the figure. The force which causes the outward motion depends on the peripheral speed of the wheel, and this in turn is proportional to the diameter of the wheel and the square of the speed of revolution; that is, the centrifugal force is directly proportional to the diameter of the fan, and the square of the number of revolutions per

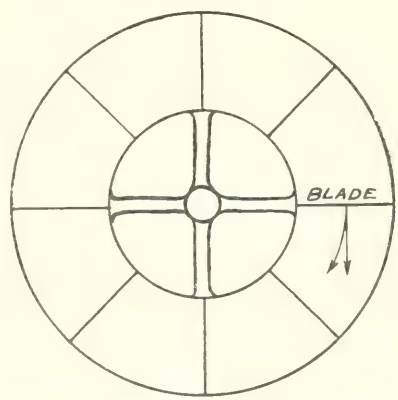


Fig. 1.—Diagram showing the principle of the Centrifugal Fan.

second or per minute. Again, we may consider the fan as an air-compressor which raises the pressure of a large volume of air by a small amount. The blades of the fan press against the air in front of them as the wheel revolves. The air immediately in front of the blades is therefore slightly increased in density or compressed. There is consequently a zone of slightly compressed air in front of the blades, and this air pushes the air in front of it and so passes into the area outside the circle of revolution of the fan. The fan is continually throwing air off at its periphery as it revolves. From Newton's Third Law of Motion we know that to every action there is an equal and opposite reaction, and from his second law that the force against the fan is equal to the rate of change of momentum of the air.

On being expelled from the fan the air is given a velocity v feet per second, which is the peripheral speed of the fan. The weight of air delivered per second being W, we have that the force $F = \frac{W}{g}v$. This force acts through a distance v feet per second. Hence the work done per second is $\frac{W v^2}{g}$. Now, if this weight of air were raised through a height H, the work done would be $W H$. Therefore $W H = \frac{W v^2}{g}$ or $H = \frac{v^2}{g}$.

H is the height of a column of air of the temperature and pressure of the air delivered by the fan, and is numerically equal to the square of the peripheral velocity of the wheel of the fan measured in feet per second, divided by the acceleration due to gravity.

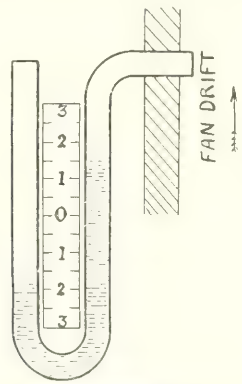


Fig. 2. Water-gauge.

The usual method of measuring the ventilating force or pressure produced by a fan is by means of the water-gauge. This instrument consists simply of a U-tube or two straight glass tubes connected by a cross-tube (see Fig. 2). One limb of the tube communicates with the drift connected with the inlet of the fan, and the other is open to the atmosphere. The difference of pressure, that is, the ventilating pressure, is indicated by the difference of level of the water in the two limbs of the gauge. In some cases an automatic recording mechanism is attached to the water-gauge, so that a continuous graph of the ventilating pressure is obtained. The relation between the water-gauge and the air-column H is given by the equation W.G. $= \frac{w H}{5{\cdot}2}$ in which w is the weight of a cubic foot of air, and the water-gauge is measured in inches. We thus have that W.G. $= \frac{w v^2}{5{\cdot}2 g}$. This is the theoretical water-gauge. No fan produces the water-gauge corresponding to its speed, however, and a co-efficient k has to be used, k being the manometric efficiency. Thus,

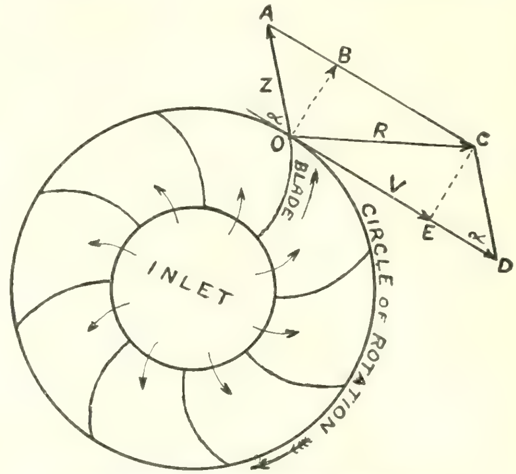


Fig. 3.—Fan with Blades bent backwards.

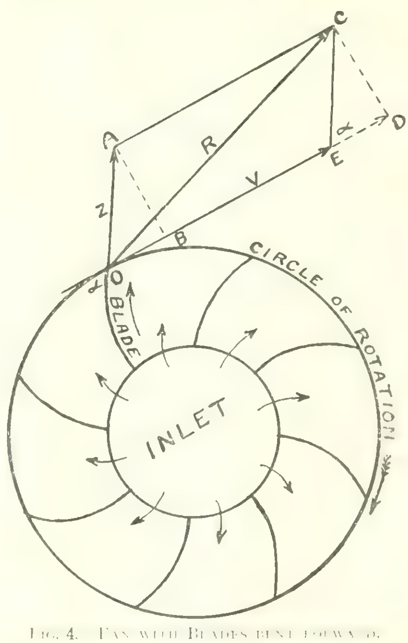


Fig. 4. Fan with Blades bent forward.

W.G. $= \frac{k w v^2}{5{\cdot}2 g}$. The water-gauge given by the formula $\frac{k w v^2}{5{\cdot}2 g}$ is sometimes called the *initial* water-gauge. A better term would be the total or gross water-gauge. The effective water-gauge is always less than this, since a portion of the total depression (or compression) is used in the fan itself. Generally from 60 to 80% of the total water-gauge produced by the fan is available for circulating the air in the mine. If less than half of the effort of the fan is available for the mine the fan is too small and the efficiency must necessarily be low.

EFFECT OF SHAPE OF BLADES.—The blades of the runner of a modern mine fan may be either straight or curved. Most of the successful fans have curved blades. The curvature may be either backwards against or forwards with rotation. For a given speed and quantity of air, the fan having blades with their concave sides discharging the air produces the highest water-gauge. This is due to the fact that the blades pitch the air forward at a speed greater than the peripheral velocity. This point is brought out clearly in the two diagrams, Figs. 3 and 4. It will be seen that the total forward velocity is greater in the case of the fan with blades trending forward than with blades which curve backwards. The formula for the theoretical column of air corresponding to the water-gauge is now (*a*) for forward curved blades: $H = \frac{v^2 + u\,v\cos a}{g}$; (*b*) for backward curved blades: $H = \frac{v^2 - u\,v\cos a}{g}$. Where u = velocity of air just before leaving the fan relative to the blades, and a is the angle between the blade and the tangent to the circumference at the point where the blade touches it.

Most modern fans, as, for example, Sirocco, Keith, Ser, Rateau, Jeffery, and others, have their blades curved forwards in the direction of rotation. Nevertheless, there are several successful fans with backward curved blades, notably the Walker and Waddle fans, both of which are still strong favourites with mine managers. The superiority of the fan with forward curved vanes over the fan with blades curved backwards is more apparent than real. The aim at most collieries and mines is to keep the water-gauge or ventilating pressure as low as possible since a high water-gauge not only means a large expenditure of power, but is also conducive to leakage, and, as was pointed out by the writer in a previous contribution to the MAGAZINE (in July, 1920), leakage is one of the chief sources of waste in the ventilation of a mine. A low ventilating pressure being a desideratum, it follows that the fact of one fan giving a higher depression than another for a given peripheral speed loses its significance. The chief points to be looked for in a fan are strength, reliability, and low internal resistance, and these are of greater importance than a slight superiority in water-gauge. Nevertheless, other things being equal, the fan with forward-trending blades is superior to the fan whose blades curve backwards. A large number of blades is more effective than a small number, but the blades must be short and care must be taken not to increase unduly the internal resistance.

The internal resistance of the fan is a matter of some importance. In the earlier types of fans, the vanes or blades commenced from near the centre, but later, when the theory of the centrifugal ventilator was more thoroughly understood, the blades were made much shorter, as, for instance, in the Sirocco type. Practically the whole of the work of the fan is done by the tips of the blades, and by cutting away the interior the resistance of the fan itself was considerably reduced. The inlet of the fan, which before was something like one-third or one-half the diameter, was now made practically equal to the diameter. In this way, owing to the small internal resistance, a fan giving the same total water-gauge is capable of operating efficiently over a wider range of mine resistance than could have been secured with earlier types.

The ideal fan would receive the air without shock and guide it towards the circumference along perfectly smooth curves, eject it at the periphery with the maximum possible velocity, and discharge it into the atmosphere with practically no velocity at all. This last point is dealt with in a subsequent paragraph on the "evasee" chimney. In its passage through the fan the air has to turn at least through one right angle, and in the case of the fan with curved blades a further angle of from 30° to 60° has to be negotiated. If the velocity of the air is great as it enters the inlet or ear of the fan, it will tend to pile up against the farther side disc. A rebound ensues, causing surging, which inevitably reduces the effectiveness of the ventilator. In the Rateau fan—due to Professor Rateau—is made what is probably the most effectual attempt to deal with the problem of guiding the air through the fan with a minimum of shock. In most fans of British or American design the matter is not dealt with quite so thoroughly, but nevertheless it is not entirely neglected.

THE ENCLOSURE OF THE FAN.—It was early found by Guibal that if the ordinary parallel-sided centrifugal fan be allowed to deliver air all round its circumference, the efficiency is very low. In order to appreciate the reasons for this ineffectiveness it is necessary to bear in mind that in a parallel-sided fan the cross-sectional area of the path of the air from the centre to the circumference increases in direct proportion to the distance from the centre. Since the same volume of air is passing through every cross-section of the fan at the same instant, it will be clear that the velocity near the periphery ought to be less than the velocity near the centre. But the centrifugal force is greatest at the periphery, and so the air is urged forward there at a greater rate than the air at the centre is able to keep up with. As a result a zone of low pressure exists in the fan, towards which air that has just been expelled from the fan attempts to rush. This re-entry of air interferes with the free working of the fan and greatly reduces its efficiency. In addition, the air leaves the fan with a high velocity, and in this way carries away a large proportion of the energy which would otherwise be available as pressure.

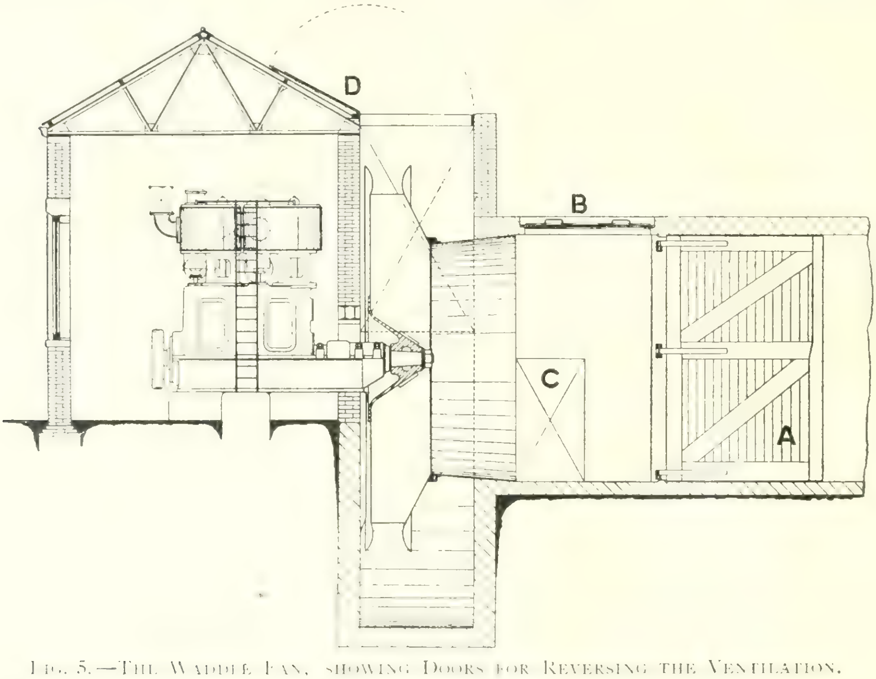


FIG. 5.—THE WADDLE FAN, SHOWING DOORS FOR REVERSING THE VENTILATION.

Guibal decided, therefore, to enclose his fan in a brickwork casing, and to restrict delivery to one point only; further, he designed the outlet in the form of a gradually expanding chimney called the "evasee". The effect of this was greatly to increase the usefulness of the fan as a ventilator.

The casing designed by Guibal closely fitted the fan, and an adjustable shutter was placed at the delivery opening so that the quantity of air could be regulated. Later it was found that a better arrangement was to place the fan eccentrically in its casing, so that it is enabled to deliver air all round its circumference. The modern fan still discharges only at one point, that is, through the evasee. The passage-way around the fan is of gradually increasing size so that the cross-section is proportioned to the volume of air delivered. The evasee is but an extension of this gradually widening passage.

THE EVASEE CHIMNEY.—The true function of the evasee is to convert velocity energy into pressure energy. It can be shown that in an open running fan in which no attempt is made to recover the kinetic energy of the discharged air, the actual water-gauge produced by the fan is only half the theoretical water-gauge. In other words the fan wastes 50% of the energy it imparts to the air.

In the enclosed fan equipped with an expanding chimney, a considerable portion of the energy existing as velocity is transformed into pressure which is available for circulating the air in the mine. The evasee increases the effectiveness of the fan as a ventilator. Most modern fans have this expanding outlet. There is one, however, which has no evasee and which discharges atmosphere, thus recovering some of the velocity energy as pressure. The device is not so effective as the evasee chimney, but it does some good. In the case of large fans of the enclosed type, the evasee and the casing are constructed of brickwork, but the smaller sizes have a sheet-iron enclosure and outlet. Indeed, it is becoming quite common practice to

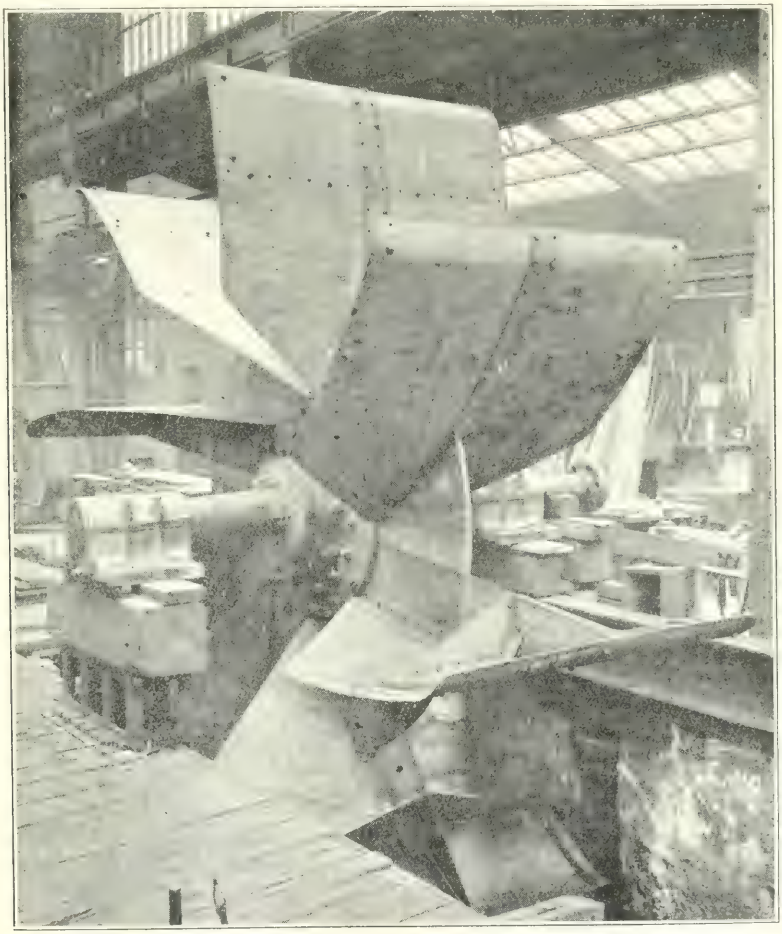


FIG. 6.—THE RUNNER OF THE WALKER FAN.

its air into the atmosphere all round its circumference. This is the well-known Waddle fan. (See Fig. 5.) Re-entry of air is prevented by reducing the width of the fan towards the circumference, and in lieu of the evasee chimney, which because of the construction cannot be employed, the fan is bell-mouthed at the periphery. The effect of the bell-mouth is to reduce the velocity of the air as it enters the external build even the larger fans completely of steel.

THE WADDLE FAN.—This fan has been in use for many years and continues to do good service. The peculiarity of the Waddle fan consists in its not being contained in an enclosure. It is practically a light hollow disc, with the sides strongly braced together by the blades. The hollow conical centre-piece admits of the end bearing of the engine projecting within the centre of gravity of the fan, so that the weight is brought almost directly over the bearing. The simplicity and effectiveness of the design will be apparent from Fig. 5, which shows a 17 ft. diameter fan with a capacity of 400,000 cu. ft. per minute at 4 in. water-gauge. The drive shown is by means of a vertical engine, although electric drive is equally convenient.

The blades of the fan are curved backwards against the direction of rotation. The fan width decreases towards the circumference so as to proportion the velocity of the air in every part of the fan to the centrifugal forces. By this device back-entry of air is prevented. The side-discs of the fan project beyond the blades, as shown in the figures, and they are turned slightly outwards towards the periphery, so as to produce an expanding outlet equivalent to an evasee chimney.

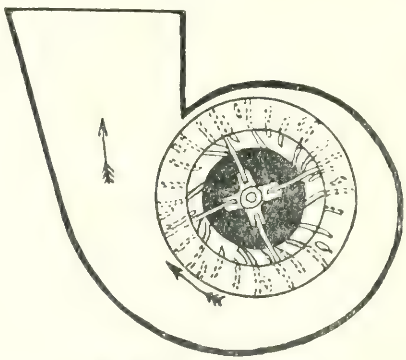


FIG. 7.—THE CAPELL FAN.

The fan takes its air from one side only. The simplicity of the necessary masonry, the short shaft, the single bearing for the fan itself, the strength and compactness of the runner, combine to make the Waddle fan an excellent ventilator.

THE WALKER INDESTRUCTIBLE FAN.—This well-known fan has done good work for many years. Its popularity depends chiefly on its strong and reliable construction, ensuring long-continued running with little attention and small running repairs. The fan has eight blades bent back against the direction of rotation of the runner. The blades are cut away towards the centre and are attached to a central disc-plate. The fan may be either single or double-inlet, and is made in sizes from 10 ft. to 15 ft. diameter. The speed of revolution may be from 150 to 300 revolutions per minute. There is an arrangement for gradually unloading the vanes as they approach the evasee. This device consists of a V-shaped shutter, which allows the air in front of each vane to be unloaded gradually. The construction of the fan is shown in Fig. 6.

THE CAPELL FAN.—This fan was originally designed in this country by the late Rev. J. Capell, but the runner has undergone various modifications. One of the more recent forms is shown in Fig. 7. The fan is of medium size, and may be run at moderate or even high speeds. Like all modern types, the casing is of the spiral form. The runner may be single or double inlet. The blades are more numerous than in the Walker, but not so numerous as in the Sirocco. Moreover, they are not all of the same length. The arrangement makes for a uniform distribution of density throughout the runner. The fan in its various modifications is employed in large numbers all over this country and in America, as well as in the British Colonies.

THE SIROCCO FAN.—This fan is largely used both in this country and in the colonies. The blades of the runner are turned forwards in the direction of rotation. By this means it is claimed that the velocity of the air leaving the runner is nearly 80% higher than that given by a fan with radial blades running at the same peripheral speed. The blades are numerous (Fig. 8), and very short radially. On this account the inlet of the fan is nearly equal to the diameter. This feature reduces the internal resistance of the fan. Double-inlet fans of this type are common, and consist simply of two single-inlet runners mounted back to back on the same spindle. The runner is placed eccentrically in the casing, which is the invariable arrangement in modern fans.

The fan is made in all sizes from 10 in. to 150 in. diameter, or more. The following selection gives some idea of the sizes and outputs in general use :—

Diameter Inches	Water Gauge Inches	Quantity cu. ft. per min.	Mine
154 (double inlet)	12½	500,000	Carlton Main, Yorkshire.
133 (single inlet)	2½	200,000	Harton, Durham.
140 (double inlet)	4	375,000	Llwynypia, S'th Wales.
98 (double inlet)	3	250,000	Bent, Hamilton, Lanarkshire.

THE KEITH FAN.—The design of this fan is somewhat similar to that of the Sirocco fan. The details of the runner of a double-inlet fan are shown in Fig. 9. Like the Sirocco fan the blades are numerous and curved forward in the direction of rotation.

The shape of the blades contributes greatly to the strength and rigidity of the runner. The inlet is large, being 10 ft. diameter in a runner whose diameter is 11 ft. The external diameter of the runner is less at the centre than at the inlet and the blades increase in depth towards the centre. The purpose of the reduction in overall diameter toward the centre is to combat the tendency for the air entering the fan to bank up against the central plate. The peripheral speed is fan is designed to deal with 400,000 cu. ft. of air per minute against a static pressure of 6 in. water-gauge. The speed is 214 revolutions per minute, and the power for driving with the fan fully loaded will be about 500 h.p.

THE BRIGHTSIDE FAN.—This fan belongs to the same class of ventilator as the Sirocco and Keith fans. The blades are numerous and curved forward in the direction of rotation (Fig. 10). The depth of the blades

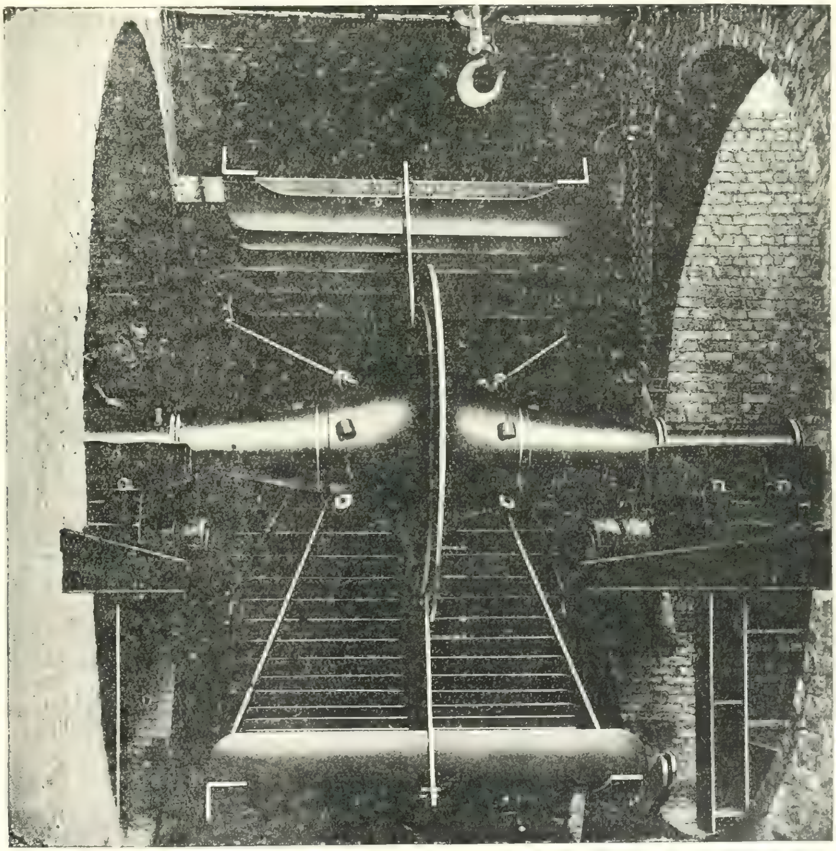


FIG. 8.—THE RUNNER OF THE SIROCCO FAN.

greatest at the outer edges of the runner, and in consequence the inductive effect is greatest there. The pull of the fan therefore diminishes slightly toward the centre, and the effect is such as to neutralize to some extent the forward momentum of the air as it enters the inlet of the fan, so that a comparatively uniform delivery of air over the whole width of the periphery is secured.

A large Keith fan has recently been installed at a colliery in South Wales. The

increases as the centre or main driving plate is approached, and they are connected to the plate so as to make the construction strong and rigid. The best mild steel is used in the construction of the runner. The main driving bosses are of conical formation, made from the best quality cast iron, each machined to take the mild steel driving plate and bored and keywayed to fit the massive mild steel driving shaft. The bearings are of the ring oiling type, fitted with phosphor-bronze

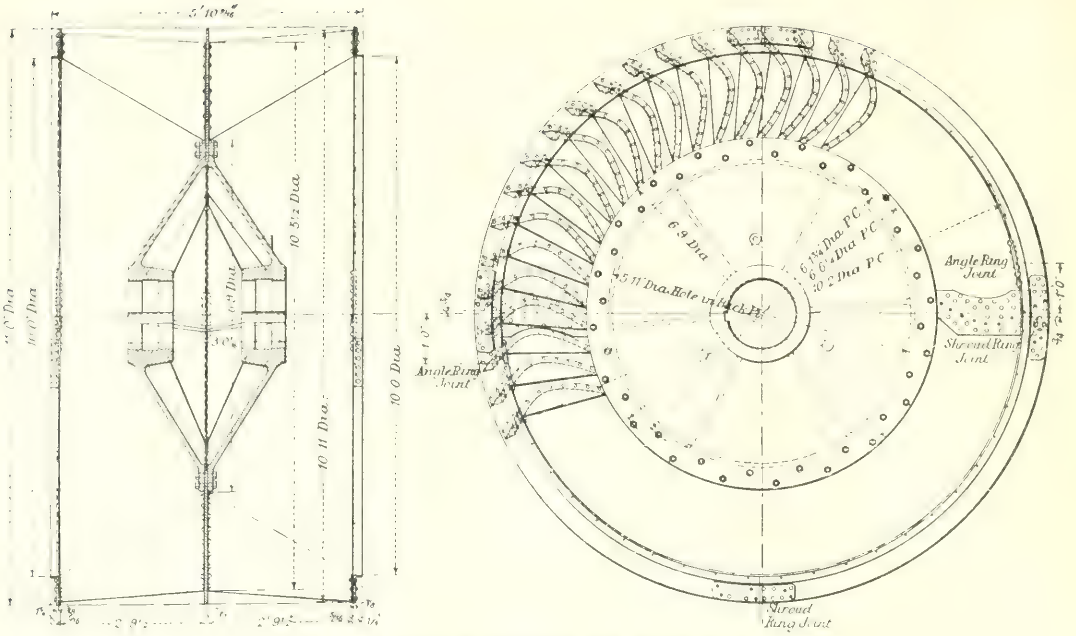


FIG. 9.—THE RUNNER OF THE KEITH FAN.

liners. A standard fan of this type 120 in. diameter will give approximately a 4 in. water-gauge, which on a mine orifice of 50 sq. ft. would give in round numbers about 250,000 cu. ft. per minute with a brake-horse-power of somewhat less than 250.

JEFFREY FANS.—The Jeffrey fans are of American design and construction. The vanes or blades are in the form of conical scoops. They are curved but discharge the air in a radial direction. The casing is generally constructed of steel, so that the fan is complete in itself. The cost for masonry when installing a fan is thus reduced to a minimum. The runner is placed eccentrically in the casing, thus following what is considered to be the best modern practice in this country. The Jeffrey Manufacturing Company claim to be the largest makers of fans in the world, and they have installed mine fans to suit almost every conceivable situation. Fig. 11 shows an installation of Jeffrey fans.

THE TURBON FAN.—The special feature of this fan is the runner which is of novel construction. It consists of a few rings

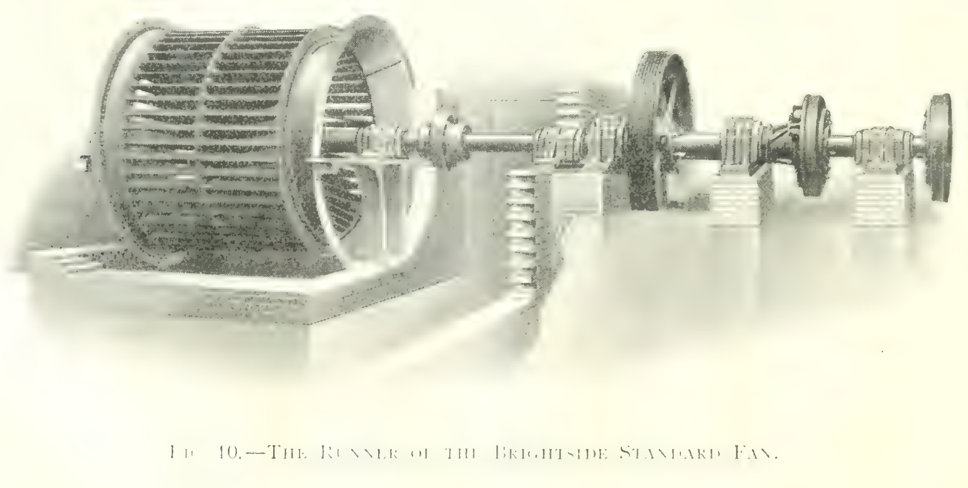


FIG. 10.—THE RUNNER OF THE BRIGHTSIDE STANDARD FAN.

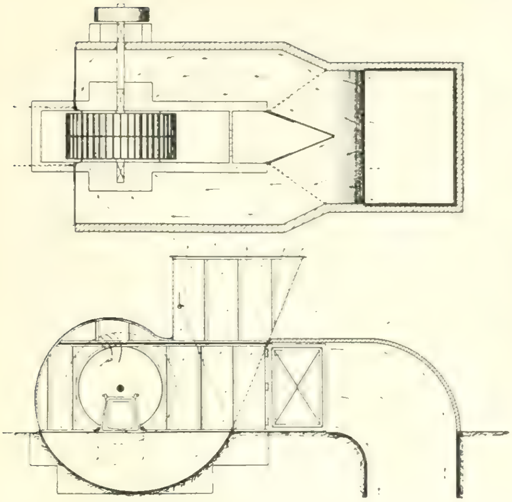


FIG. 11.—DOUBLE-INLET JEFFREY EXHAUST REVERSIBLE FAN.

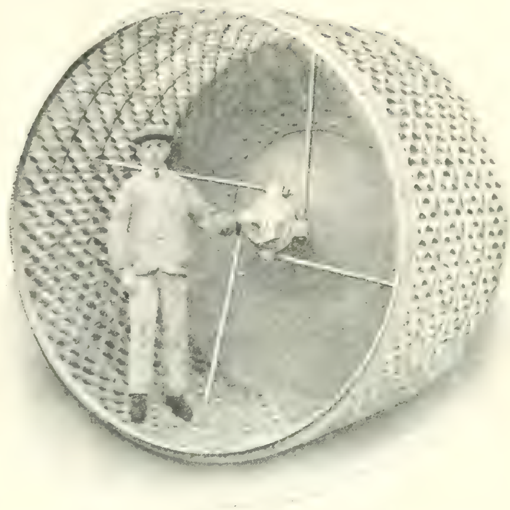


FIG. 12.—RUNNER OF THE TURBON FAN.

pressed into a corrugated shape by means of suitable dies, made to interlock with each other (see Fig. 12). The interlocking ridges and corresponding recesses are formed in the press at the points where the ring makes contact with the neighbouring rings when a set of them is assembled to form a runner. The corrugated rings are secured between an end driving disc and a holding ring by means of stay bolts which bind the whole firmly together. No rivets are used in the blade rings, so that the runner can be readily fitted together or taken apart. The design of the runner gives good torsional strength and silent running. Moreover, the rings can be reversed so that the runner is suitable for revolving in the opposite direction, and when required the casings are also made reversible, so that the same fan is suitable for conditions which call for either clockwise or counter-clockwise rotation. The casing of the fan is of the ordinary spiral form. A Turbon fan capable of dealing with 166,000 cu. ft. per minute at a speed of 285 revolutions per minute, and giving a water-gauge of 4 in., was recently installed at a South Wales colliery. The fan is single-inlet, and 80 in. diameter. Double-inlet fans are constructed by placing two single-inlet runners back to back and mounted on the same shaft. The Turbon fan is made in all sizes up to 100 in. diameter, which size has a capacity of over 600,000 cu. ft. of air per minute at a water-gauge of 6 in.

(To be concluded.)

The Institute of Metals

The annual meeting of the Institute of Metals will be held in London on March 8 and 9, when a number of important papers are to be presented for discussion. The annual dinner will be held at the Trocadero Restaurant on Wednesday, March 8. The annual May lecture will be delivered on May 3 by Sir Ernest Rutherford, F.R.S., on "The Relation of the Elements." The discourse should throw fresh light on the much-debated subject of the possible transformation of one metal into another. The autumn meeting of the Institute will be held—for the first time—at Swansea on September 20 to 22. A large gathering is expected in this important metallurgical centre. From October to December (as well as during the present quarter) meetings of the various local sections of the Institute will be held in London, Birmingham, Sheffield, Glasgow, Newcastle-on-Tyne, and elsewhere. In view of the attractive nature of the programme for the ensuing year it is expected that the growth of the Institute in 1922 will be even greater than it was last year, when the membership increased from 1298 to 1410, a record year's growth. The Institute has just issued a pamphlet of 32 pages giving in summary form the results of over ten years' research into the causes and prevention of corrosion in condenser tubes. The pamphlet can be obtained, price 2s. 8d. post free, from the Institute of Metals, 14, Members' Mansions, London, S.W. 1.

THE BAUXITE RESOURCES OF INDIA

By CYRIL S. FOX, B.Sc., M.Inst.M.E., F.G.S.

Geological Survey of India

The Author describes the Indian bauxite deposits, and discusses the possibility of establishing an aluminium industry in India

OCCURRENCE AND CONSTITUTION OF BAUXITE.—Although aluminium is one of the commonest metals in the earth's crust, it is not found in nature as a metal. Its compounds are, however, very numerous. A large number of the common rock-forming minerals contain aluminium as an important constituent, and it is present in all ordinary clays. Corundum and the precious stones, ruby and sapphire, are oxides of aluminium. In spite of the fact that there are many and widespread occurrences of aluminium compounds, very few of them admit of the economic separation of the metal. The commercial production of aluminium is at present almost entirely obtained from the peculiar clay-like substance known as bauxite. This ore of aluminium occurs in various parts of the world. It has been extensively worked in the south of France, and from there supplied to the great reduction works of Great Britain, Norway, and Switzerland. During the war the Central Powers obtained their supplies of bauxite from the Bihar Mountains of Hungary (now allotted to Roumania), and from occurrences in Dalmatia. In Italy bauxite is found and worked in the Central Apennines and in the Isthmus of Istria. The large occurrences of bauxite in Arkansas, Georgia, and Alabama have long supplied the wants of the United States and Canada. More recently the bauxites of South America (British Guiana, etc.) have been exploited.

The analyses (Table I) of bauxite from the above-mentioned areas will give some idea of the quality of the substance which has been profitably utilized.

Bauxite occurs associated with the interbedded laterite in the basaltic lava flows of County Antrim in Ireland. This rock is still mined at various places, but it is not used in the alumina works at Larne Harbour for purification and subsequent reduction to aluminium elsewhere. It is generally very siliceous, but is most interesting from the point of view that the bauxites of India also occur with laterite.

In 1807 Francis Buchanan (— Hamilton) gave the name "laterite" to a remarkable red, ferruginous, hard, residual clay of scoriaceous appearance, which he met with in the Malabar and Kanara territories of South India. He, however, did not record an analysis of the substance. In 1820 P. Berthier published, separately, two analyses of clayey materials; one (A, see below) of a peculiar clay substance from Baux, near Arles in Provence (France), and the other (B) of a ferruginous weathering product of rocks in the Futah Jallon country of West Africa.

	A.	B.
	%	%
SiO_2	—	2·8
Al_2O_3 ...	52·0	8·7
Fe_2O_3 ...	27·6	77·2
H_2O	20·4	11·4

Berthier named A "bauxite," but does not appear to have drawn any inferences regarding a relationship between A and B. F. R. Mallet in 1883 drew attention to the high alumina contents of some Indian laterites (Katni), and compared the Indian laterites with the Irish ferruginous bauxites. It was not, however, till the end of the last century that Max Bauer, working in the Seychelles, proved that bauxite and laterite were varieties of the same kind of rock, the one highly aluminous and the latter distinctly ferruginous, their composition being, almost entirely, mixtures of the hydroxides of aluminium and ferric iron with, as a characteristic quality, an absence of silica. Soon after the publication of Max Bauer's work, the Geological Survey of India made known the occurrence of workable deposits of bauxite in various parts of India. Almost twenty years have elapsed since that information was made public, and although attempts have been made to develop these occurrences, no serious production of bauxite has yet resulted. During the war this unsatisfactory situation was evident, and the Government of India have had the known bauxite occurrences of the country investigated by the Geological Survey of India, and a memoir of the subject (now in the press) is about to be issued.

THE WORLD'S PRODUCTION.—The present situation with regard to bauxite in India can be summarized thus: (1) there are known to be occurrences of high-grade bauxite, and there are also known to be good sites for hydro-electric power; (2) most of the schemes put forward for the development

TABLE 1.—ANALYSES OF CHARACTERISTIC BAUXITES.

	France.				Hungary.		Dalmatia.
	1	2	3	4	5	6	7
1. SiO_2	0·80	0·80	0·29	13·3	1·49	0·80	0·89
2. TiO_2	2·80	3·50	0·80	2·4	3·12	2·80	—
3. Al_2O_3	58·6	76·4	60·60	63·7	59·66	65·5	51·85
4. Fe_2O_3	26·2	4·8	26·0	5·5	23 66	21·3	26·82
5. CaO	—	—	—	—	—	—	—
6. MgO	—				—		—
7. H_2O (comb.)	10·9	14·3	10·4	14·3	11·81	9·96	19·97

	Italy.		United States.				British Guiana.	
	8	9	10	11	12	13	14	15
1. SiO_2	2·79	7·91	2·90	2·00	10·13	0·62	2·73	1·00
2. TiO_2	1·27	—	3·40	3·50	—	1·05	0·10	1·10
3. Al_2O_3	57·6	58·85	58·21	62·05	55·59	64·91	64·38	70·90
4. Fe_2O_3	26·55	18·62	3·60	1·66	6·08	0·28	0·50	0·80
5. CaO	—	0·30	—	—	—	—	—	—
6. MgO	—	0·37	—	—	—	—	—	—
7. H_2O (comb.)	11·71	13·27	31·89	30·31	28·99	33 00	32·29	26·30

1 and 2. Loupain (Herault), analyses by M. Blot for M. Arsandaux. 3 and 4. La Caire (Var), analyses ditto. 5. Cucul (Bihar Mts.), analyses by M. Blot for R. Lachmann. 6. Dealul Cruci (Bihar Mts.), analysis ditto. 7. Dernis (Dalmatia), analysis by Kucan for Kispatic. 8. Lecce dei Marsi (Abruzzo), analysis given by G. Aichino. 9. Pietraroja, Benevento (Campagna), analysis given by Mattiralo. 10. Cherokee Co. (Alabama), analysis given by H. McCalley. 11 and 12. Arkansas, analyses given by J. C. Branner. 13. Floyd Co. (Georgia), analysis given by T. L. Watson. 14. Yarikita River (British Guiana), analysis given by J. B. Harrison. 15. Essequibo River, analysis ditto.

of bauxite have had in view the electrolytic reduction of aluminium and have not succeeded in attracting influential practical firms ; (3) it seems, although Sir Thomas Holland called attention to the matter fifteen years ago, not to be sufficiently known that bauxite is not used directly in the existing types of electrolytic furnaces for the separation of aluminium, and that pure alumina must be first obtained ; (4) further, the following factors, that is, the world's market for bauxite, the presence of other more favourably located occurrences, the control of the aluminium production of the world, and the Indian demand for aluminium, have evidently not been thoroughly understood ; (5) and finally, the amounts of bauxite so far produced in India have been obtained for experimental purposes only, and these quantities are, of course, trifling compared with what will be possible when the right people become interested.

Nearly all the bauxite that is produced (see Table II) is purified to alumina for reduction to aluminium (see Table III). The imports of aluminium and aluminium salts into India are seen in Table IV (see page 85). A small, though increasing, quantity of raw bauxite is being used for other manufactures, namely, artificial abrasives, as basic refractory bricks for furnace linings, and in the filtration and decolourizing of mineral oils and other organic substances. And an appreciable quantity of the bauxite which is purified to alumina, both as the hydrate and the anhydride, is being used for other purposes than its reduction to aluminium, for instance, in the manufacture of the sulphate and other aluminium salts, in the glass industry in making heat-resisting glassware, etc. It is impossible in the absence of statistics to show in what proportions the bauxite production of the world is allocated in these several industries. In the United States the percentages are said to be roughly as follows :

	%
Purified to alumina for aluminium	69
Purified to alumina for chemical purposes	10
Fused for manufacture of abrasives	19
Used direct for refractory materials	2

The aluminium production of the world is in the hands of a few powerful firms, whose approximate output for 1920 is as shown below. The estimate of these figures is based on private inquiries :—

	Metric Tons.
Aluminium Company of America Northern Aluminium Co. of Canada	95,000
British Aluminium Co. (Great Britain and Norway)	12,000
The Aluminium Corporation Ltd.	800
L'Aluminium Francaise (France and Norway)	12,000
L'Aluminium Industrie Aktien Gesellschaft (Switzerland and Austria)	10,000
L'Alumina Italiano (Italy)	2,000
German Government Works	10,000
	141,800

These outputs do not represent the full producing capacity of the various firms engaged. Some idea of the size and ramifications of these big aluminium firms may be imagined by taking the British Aluminium Company (Great Britain and Norway), the pioneer firm in Great Britain, as an example. Although still working the Irish bauxites of County Antrim in a subsidiary way, this firm obtains practically all its ore for reduction and other purposes from the bauxite concessions it possesses in the Department de Var (France). They have alumina works at Larne Harbour (County Antrim) and at Burntisland (Firth of Forth, Scotland), in which this French bauxite is treated. These purification plants are not only capable of supplying all the burnt alumina (the anhydride) required for the needs of the company's furnaces, but in addition meet the various demands, for example, the hydrate of alumina for chemical works, making aluminium sulphate, etc., the anhydride for manufactures of special heat-resisting and laboratory glassware, etc. The electrolytic furnaces, for the production of aluminium ingot, blooms, bars, and granulated aluminium, are situated in two factories, one at Kinlochleven (Argyll) and the other at Foyers (Inverness), in Scotland. There is also an elaborate carbon electrode factory at Kinlochleven. For the manufacture of the usual sheets, circles, rods, wire, tubing, etc., there are special rolling mills at Milton and Warrington, in England. In addition to the above works, the British Aluminium Company possesses two reduction plants and an electrode factory in Norway. They also have, owing to the strategic location of their many works, other interests, —for instance, in shipping and coal—and have been steadily extending their activities. The same general remarks apply to the other big groups who supply the world's demand for aluminium.

These firms would not and could not allow new and distinct organizations to capture any of their large markets if they intend to maintain their dominating positions. Consequently a new company, however well favoured by advantages in the location and quality of its bauxite occurrences and the cheapness of its hydro-electric power, would have to be prepared to face very severe trade competition during the period of exploiting a particular market. In such circumstances, unless the new company held an overwhelming advantage with regard to a particular market, perhaps it would be best for all concerned if the new company could arrange terms with the firm in whose sphere of influence it contemplated operations.

THE INDIAN POSITION.—The foregoing remarks concerning the prospects of a new company with great natural advantages must not be presumed to refer to India. It is the purpose of this article to discuss this aspect of the Indian bauxite occurrences. It has yet to be demonstrated whether the Indian bauxites are attractive, and, if they are, to indicate the most efficient methods that might be adopted for their development. To elucidate the subject, I shall endeavour to answer the following questions :

(1) What are the field relations of the Indian bauxites ?

(2) Are there any favourably located Indian occurrences of marketable ore ?

(3) Will it be possible to produce alumina cheaply in India ?

(4) Is it possible to manufacture cheap aluminium in India ?

(5) How is it possible to utilize the Indian bauxites ?

(1) FIELD RELATIONS OF THE INDIAN BAUXITES.—It has already been stated that the Indian bauxite is an aluminous laterite. The general manner of occurrence of the laterites of the Peninsula are shown in Fig. 1 (page 86). In nearly every case the primary or *in situ* laterite represents the prolonged weathering product of the basaltic lava flows of the Deccan. Also, in the areas concerned, the drainage of the Peninsula is from those great plateau regions where the primary laterite is developed, and from which the lateritic debris, for millions of years, has been carried down to the lower country to the north, south, east, and west.

On close investigation it has been found that primary laterite can only form under tropical conditions subject to dry and wet seasons or monsoons, and only on elevated plains or gently sloping land surfaces which are not subject to appreciable erosion. Further, that the rocks thus exposed to prolonged atmospheric weathering must consist of materials containing appreciable proportions of alumina and iron oxide, and that the texture of the weathered rock must be sufficiently porous. In addition, the infiltrating water must remain in contact with the porous rock for some time, although it eventually drains away. No laterite in India is known to have formed

Table II.—World's Production of Bauxite, in Long Tons.

Country.	1916	1917	1918	1919	1920
United States	425,100	568,690	605,721	376,566	521,308
France	104,493	118,973	(a)	160,865	186,693
United Kingdom	10,329	14,724	9,589	9,221	(a)
Italy	8,739	7,666	7,676	2,924	37,360
India	750	1,363	1,192	1,682	(a)
British Guiana	—	2,790	4,199	1,967	29,399
Spain	—	—	453	1,751	—
Total	549,411	714,206	—	554,976	

(a) Statistics not available.

Table III.—Estimated World's Production of Aluminium in Metric Tons.

Year.	Austria.	Canada.	France.	Germany.	Great Britain.	Italy.	Norway.	Switzer-land.	United States.	Total.
1913	5,000	5,916	(a) 13,503	800	10,000	(a) 874	2,500	10,000	29,500	78,093
1914	4,000	6,820	(a) 9,967	800	8,000	(a) 937	2,500	10,000	40,600	82,924
1915	2,500	8,490	(a) 6,020	2,000	6,000	(a) 904	3,500	12,500	45,000	86,914
1916	5,000	8,800	(a) 9,604	8,000	4,000	(a) 1,126	6,000	15,000	63,000	120,230
1917	5,000	11,800	(a) 11,066	15,000	6,000	(a) 1,740	8,000	15,000	90,700	164,306
1918	8,000	15,000	(a) 12,023	25,000	14,000	(a) 1,715	7,500	15,000	102,000	200,328
1919	5,000	15,000	(a) 12,200	15,000	10,000	(a) 1,673	4,000	15,000	90,000	167,874
1920	2,000	10,000	(a) 10,000	10,000	7,116	(a) 1,200	4,000	12,000	90,000	146,316
Estimated Capacity	10,000	15,000	20,000	40,000	14,000	8,000	20,000	15,000	115,000	257,000

(a) Official figures.

Table IV.—Imports of Aluminium and its Compounds into India.

From Annual Statement of the Sea-borne Trade of India (ending March 31 each year), Department of Statistics, India.

		1918–19.	1919–20.	1920–21.
(a) Unwrought Aluminium (ingots, blocks, bars, etc.).	Cwt.	9,129	8,195	18,131
	Rs.	14,80,283	6,55,320	16,47,726
(b) Wrought Aluminium (sheets, circles, etc.).	Cwt.	2,462	14,034	40,215
	Rs.	7,59,234	17,70,153	62,74,149
(c) Other manufactured Aluminium ware.	Cwt.	48	955	4,291
	Rs.	8,669	1,09,509	8,43,537
(d) Aluminium Sulphate.	Cwt.	53,196	64,013	101,961
	Rs.	4,34,947	4,33,668	8,43,417
(e) Alum.	Cwt.	12,542	64,119	72,293
	Rs.	3,01,661	6,97,056	9,37,882

below permanent ground water-level, nor has laterite been found above an altitude of 5,000 ft. in the Peninsula. When the above-mentioned conditions exist lateritization may begin.

The south-west monsoon, which causes the wet seasons in India, is due to a moisture-laden current of air from the Indian Ocean to the hot land to the north, and could, therefore, not have been established until the break-up of the Gondwana continent. This took place at the close of the Mesozoic period. In verification of this it may be stated that no Indian laterite has been found which is older than beds of Upper Cretaceous age. There are, however, laterites of all subsequent ages, that is, from the early Eocene millions of years ago, to those in process of formation to-day.

The outline sections (Fig. 2, page 86) show how during a vast period of time a laterite-capped plateau may, as a result of lateral drainage, assume the detached position many laterite-capped plateaux are frequently found to occupy on old watersheds. The enormous lapse of time may be gauged when it is stated that many plateaux a few miles apart, although of equal altitude, are now separated by valleys 2,000 ft. deep; and from field experience it has been found that bauxite only occurs in association with the oldest laterites, either as irregular lenticular masses in the primary laterite mantle itself, or as accumulations of boulders on the slopes or in the valleys below scarps of primary laterite. The detrital accumulations of bauxite are seldom found more than a few miles from their source

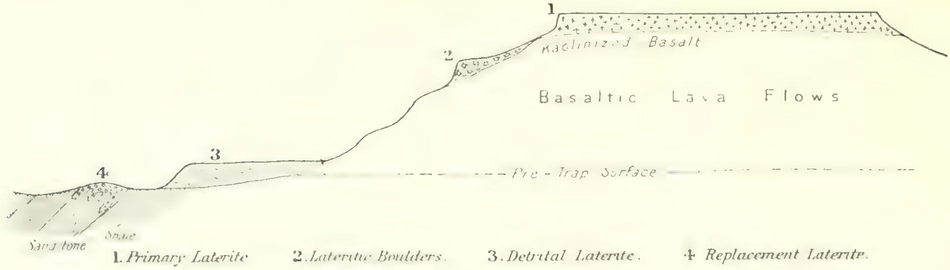


FIG. 1.—GENERAL MANNER OF OCCURRENCE OF LATERITES IN PENINSULAR INDIA.

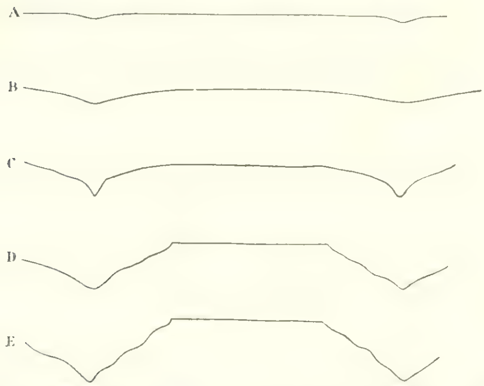


FIG. 2.—THE LINES A, B, C, D, E, SHOW STAGES IN THE DEVELOPMENT OF AN ISOLATED PLATEAU WHICH HAS LARGELY ESCAPED SURFACE EROSION; THUS THE DEPTH OF POROUS DECOMPOSED ROCK ON THE OLDEST OF SUCH PLATEAUX MAY BE CONSIDERABLE.

of origin, and sometimes, as in the Rupjar valley of Balaghat, these agglomerated deposits may be richer than the laterite scarps from which they have derived their material. In such cases a natural separation has obviously taken place; the softer ferruginous matter has been broken up and washed away, leaving the harder boulders of rich aluminous material behind. It appears to be useless to search for bauxite in those detrital laterites which occur far from regions where primary laterite has been formed. It is, therefore, most profitable to restrict one's search to the oldest watersheds of Peninsular India.

The occurrence of bauxite in a capping of primary laterite may be taken as an indication of a long interval of time during which the laterite mantle has been yearly subjected to the leaching effects of warm percolating rain-water. The yearly movements of the underground water in the porous capping of a decomposed weathered rock mantle are shown in Figs. 3 to 8 (page 87).

It requires little imagination to conclude that very powerful chemical alterations must eventually result if these successive washings, drenchings, and dryings are yearly repeated, even for a million years. Most of the soluble and much of the fine colloidal matter would be removed, either in solution or suspension.

It is thought by many chemists that when rock silicates are subjected to prolonged atmospheric weathering they break down into colloidal hydroxides (hydrosols), and these substances develop electric charges, some positive (usually the bases like ferric oxide and alumina), others negative (like silica hydrosol), with respect to each other and the electrolyte in which they are contained. (See *Chemistry of Colloids*, by W. W. Taylor, 1915.) Further, that these oppositely charged hydrosols, if not in any way protected or separated, mutually precipitate each other, not as amorphous alumino-silicates, but as mixtures of single gels. (See "A Short Survey of Physics and Chemistry of Colloids," by Dr. Th. Svedberg, in a publication by the Department of Scientific Industrial Research, London, 1921.)

In recent years another aspect of the case, with particular interest regarding a porous decomposed rock mantle, has developed. (See papers on "Electrokinetic Phenomena," in the Reports on Colloid Chemistry, and its general Industrial Applications, Department of Scientific and Industrial Research, London, particularly a paper on "Electrical Endosmose," by T. R. Briggs, 1919, pp. 26–27.) Dr. Briggs gives four distinct processes:—

(1) When an electric potential is applied to the opposite sides of a porous diaphragm immersed in an electrolyte, the liquid is forced through the diaphragm with the current. The phenomenon is called electrical endosmose. It was applied by Count Schwerin (see *Zeitschrift für Electrochemie*, 9, p. 739, 1903) for the dewatering of peat. The peat acted as the porous diaphragm, and was placed between two metal plates, one being a perforated plate. When the

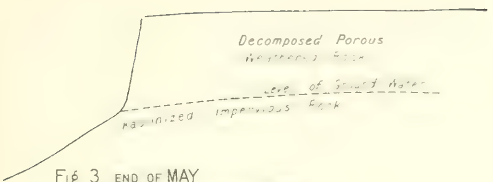


Fig 3 END OF MAY
Average Mean Temperature 96° F

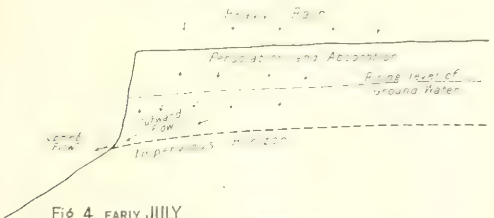


Fig. 4. EARLY JULY
Average Mean Temperature 85° F

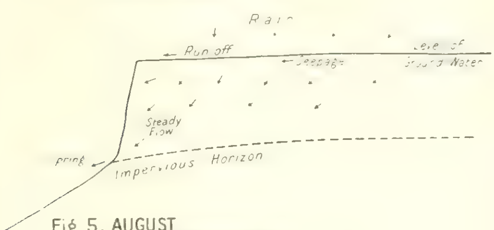


Fig. 5. AUGUST
Average Mean Temperature 80° F

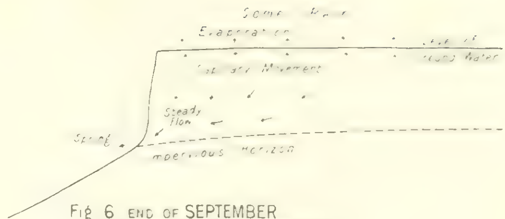


Fig 6 END OF SEPTEMBER
Average Mean Temperature 82° F

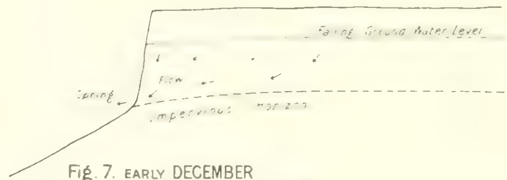


Fig. 7. EARLY DECEMBER
Average Mean Temperature 68° F

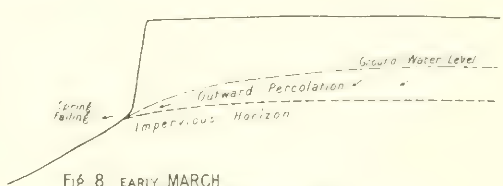


Fig 8 EARLY MARCH
Average Mean Temperature 80° F

plates were connected with a source of electric potential and the switch closed, water poured from the peat through the perforated plate, which had been made the negative pole or kathode of the circuit.

(2) If the solid instead of being in the form of a porous diaphragm exists in a state of suspension, as in a clay slip, the solid migrates through the liquid to one or other pole of an electric circuit when a current is passed through the slip. This phenomenon is known as cataphoresis. It has been developed in practical form, as the electro-osmose machine, by Dr. Ormandy, for the purification of clays. (*The British Clayworker*, p. 9, 1913; see also paper on "Colloidal Chemistry," by A. B. Searle, p. 113, British Association, Cardiff, 1920.)

(3) If as in (1) the solid is fixed in the form of a porous diaphragm, and liquid is forced through its pores in one direction, then a difference of potential is developed between the extremes of the diaphragm and an electric current may be established. This current has been proved, and is known as Quincke's current. (See papers by Quincke in *Pogg. Ann.*, 107, p. 1, 1859, and 110, p. 38, 1860.)

(4) If the solid in a finely divided condition is dropped through the liquid, a difference of potential is established between the upper and lower liquid strata. This is known as Billitzer's experiment. (See *Drude's Ann.*, 11, p. 937, 1903.)

The whole subject of electrokinetic phenomena is full of interest of a practical nature, and the literature of colloidal chemistry contains many references.

If therefore a laterite mantle be treated as a porous diaphragm, and the percolating rainwater be considered as the electrolyte, it is evident that electrokinetic phenomena must occur. The steady downward movement of the percolating water with its discharge from springs along the base of the laterite scarp will not be the only influence at work tending to separate the colloidal and soluble constituents. The question may well be asked if any peculiarities have been noticed in the disposition of the various constituents in an old laterite mantle. Yes, it is not uncommon to find a structure similar to that shown in Fig. 9. I had noted and been confused by this structure for a long time. It was met with in Western Chota-Nagpur at Dudmatiapat near

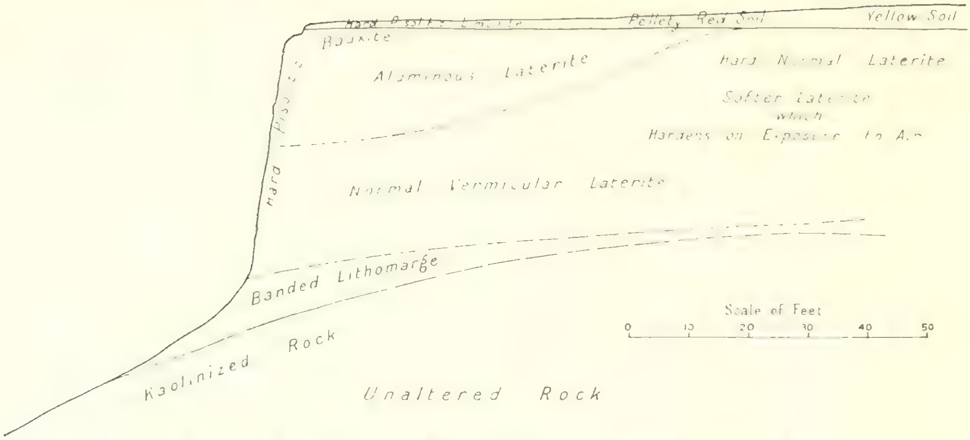


Fig. 9.—Typical Structure of Oldest Plateaux with Primary Laterite.

Lohardaga, and several other places. It was seen again in Sirguja State, the Jabalpur district, in Kolhapur, and in Belgaum, places nearly 1,000 miles apart. It was not until my colleague, Dr. W. A. K. Christie, suggested an electrokinetic explanation that the whole problem became tangible.

The degree of separation into the various constituents shown in the section (Fig. 9) is in many instances very remarkable. The almost pure pisolitic limonite covering (or as Lacroix calls it in West Africa, *cuirass de fer*) is abruptly underlain by a rich cream to bluish-grey bauxite, which in turn passes downward into a more and more ferruginous laterite (usually with a vermicular structure), until finally at the base there occurs the peculiar, complicated, laminated lithomarge composed of white kaolin, with thin sheets of ferruginous clayey matter. It would be tedious to try and explain the cause of this extraordinary structure. It is enough to say that the leaching action of the groundwater, with its downward percolation and outward discharge, the strong upward capillary action at the close of rains, and the migration of the colloidal sols and gels under the influence of the electrokinetic phenomena, which are suspected to occur, must all play important parts in the separation of the various constituents. All these processes, operating for an immense period of time, are considered to have produced the structure which has been found in the oldest primary laterite cappings. The complete structure depicted in Fig. 9 may not always be seen owing to the denudation which has eventually diminished the extent of the original plateaux. In some cases a little hillock almost entirely composed of rich bauxite remains, in others but little bauxite occurs even on a large tableland. A good development of the underlying lithomarge, however, is usually indicative of an attractive occurrence of bauxite.

There is another peculiarity attached to the bauxite portions of a plateau capped with primary laterite. Fig. 10 (p. 89) represents a plan of a cluster of residual plateaux, evidently parts of a single large tableland. It has been repeatedly found that bauxite is usually better developed under those channels of the surface drainage of a plateau which have existed from the earliest days of the laterization. In some cases these channels are in existence to-day as watercourses or shallow stream-beds which discharge the run-off water into the re-entrant portions of scarps. In other cases the old drainage lines have been deflected or cut off by the active erosion of deep lateral valleys. It is, as a general rule, more economical in time to search re-entrant scarps, and later, as the prospector becomes more efficient and is able to piece together the older physical geography and its lines of drainage, to search those other positions where the drainage used to be. This can often be done by a careful study of a good topographical map. I tried an experiment of this kind, in the Topla highlands of Balaghat, a tract I did not visit. I explained matters to the Deputy Commissioner of the District, and he sent instructions to village people in the neighbourhood of the suspected occurrences. In six out of seven cases they brought me specimens of bauxite.

From what has been said and a study of Figs. 9 and 10, it is most disconcerting to

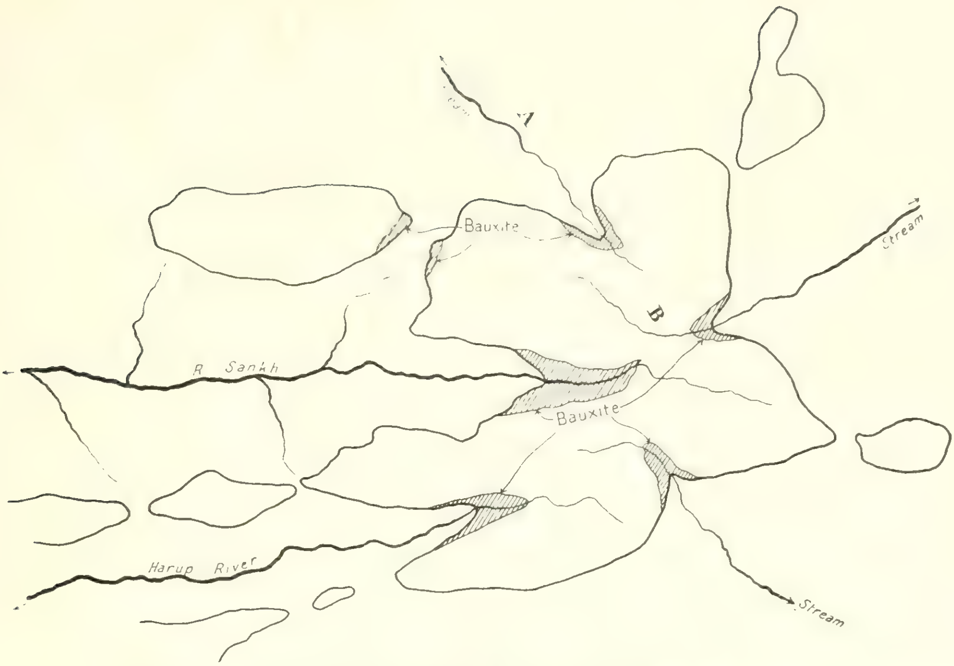


FIG. 10.—MAP SHOWING POSITION OF BAUXITE ON LATERITE PLATEAU.

realize that in the majority of cases the bauxitic portion of a mantle of primary laterite is a very small part of the whole mass of the laterite. It is impossible to warn prospectors sufficiently regarding an optimistic calculation of the amount of bauxite in a primary laterite plateau. I have known cases where, because of an exposed cliff section, of 15 to 20 ft. of bauxite seen for about 60 yards along the scarp margin, calculations were made for the cubical contents of a plateau nearly a mile long by 500 yards broad. In this instance the bauxite did not extend 100 yards into the plateau, and the exposed section showed the maximum depth and length of the occurrence. There are no excuses for miscalculating debris on a hill slope or in mistaking it for primary laterite. I have not seen a greater vertical section than 60 ft. of primary laterite, and never more than 30 ft. of bauxite in the hundreds of places visited in Western Chota-Nagpur, Sirguja, Rewa, Mandla, Balaghat, Jabalpur, Seoni, Satara, Kolhapur, Belgaum, and Ratnagiri. In valleys below scarps of primary laterite there may be greater thicknesses in the more uniform accumulations of detrital bauxite.

The composition of the various portions of a laterite-capped hill of basalt, as shown in Fig. 9 would be, taken vertically down the section, approximately as in Table V opposite.

These analyses do not represent samples actually taken from a single scarp, but are put together to show the kind of variation that may be expected at intervals of 8 ft. in a vertical section like Fig. 9. The low silica percentage in the normal laterites would often make them suitable for purification to alumina by the Bayer process.

Table VI opposite gives analyses of Indian bauxite from various parts of the Peninsula.

(2) MARKETABLE ORES IN INDIA.—From what has already been said it may be presumed that most of the occurrences of bauxite in India occur on or just below the surface of the ground, and can be quarried or dug out. In one important case a rich area of bauxite lies under about 4 ft. of soil in low water-logged ground, but alongside the main railway line immediately south of Katni-Murwara in the Jabalpur district of the Central Provinces. In Jammu (Kashmir) the bauxite, though exposed in a scarp, passes under beds of Eocene age and would, once the exposed mass was worked out, have to be mined like the bauxites of County Antrim in Ireland. The location of bauxite occurrences, containing ore of a composition given in columns B and C in

TABLE V.—COMPOSITION OF MATERIAL AT VARIOUS SECTIONS AS FIG. 9.

	A	B	C	D	E	F	G	H	I
	%	%	%	%	%	%	%	%	%
SiO_2	3·20	0·66	3·66	2·36	64·85	41·88	37·31	47·44	47·34
TiO_2	2·40	8·90	2·56	1·76	?	7·76	3·33	1·71	1·87
Al_2O_3	10·40	58·40	56·88	46·63	22·05	23·47	27·85	16·75	14·30
Fe_2O_3	70·00	1·31	5·52	23·67	2·80	10·55	17·35	4·10	4·89
FeO.........	—	—	—	—	—	—	—	10·79	13·49
CaO.........	—	—	—	—	1·45			10·63	9·36
MgO.........	—	—	0·44	1·20	1·08	1·77	0·76	6·54	7·72
Alkali.......	—	—	—	—	—	—	—	?	?
H_2O dried at 105° C.....	14·00	31·54	30·12	24·49	5·12	14·75	13·40	2·20	1·23

A. Approximate analysis of pisolitic limonite cover (*Cuirass de fer*). B. Pisolitic grey to cream-coloured bauxite. C. Cream to pink bauxite. D. Normal laterite (TiO_2 sometimes high). E. White lithomarge (siliceous). F. Pink lithomarge (Panhala). G. Kaolinized basalt (deeply altered). H. Basalt (Sirguja). I. Basalt (Kolhapur).

TABLE VI.—ANALYSES OF INDIAN BAUXITE.

	Jabalpur, C.P.			Western Chota-Nagpur, B. & O.			Balaghat, C.P.	
	1	2	3	4	5	6	7	8
SiO_2	1·18	1·40	2·70	0·08	2·32	·30	·58	1·40
TiO_2	8·80	3·20	5·96	6·04	10·26	7·40	10·24	6·00
Al_2O_3	60·23	65·10	54·76	60·76	59·99	66·98	58·83	58·40
Fe_2O_3	2·64	1·84	10·08	4·52	3·94	5·92	2·70	5·00
CaO..................	0·82	0·45	—	—	—	—	—	—
MgO..................	0·30	—	—	—	0·25	trace	—	—
H_2O (comb.)..........	25·40	28·10	25·90	29·45	23·40	21·40	26·80	28·50
Alkali and moisture, etc.	0·63	—	—	—	—	—	0·65	0·70

	Kolhapur.		Belgaum.		Ratnagiri.	Jammu.	
	9	10	11	12	13	14	15
SiO_2	1·44	3·44	1·89	1·56	3·01	12·85	14·40
TO_2	6·32	7·00	7·90	3·00	2·16	3·38	2·45
Al_2O_3	62·32	59·35	55·86	61·49	51·75	69·90	67·20
Fe_2O_3	2·65	4·25	7·08	7·99	14·60	1·08	0·80
CaO.............	trace	trace	—	0·12	—	—	—
MgO.............	0·38	0·64	0·24	0·48	0·82	—	—
H_2O (comb.)	26·27	25·00	27·10	25·15	27·30	10·90	13·15
Losses, etc.	0·28	0·32		0·21	0·39	—	—

1. Bargawan hill (Katni), analysis by R. V. Briggs for Holmes, Wilson & Co. 2. Tikaria (Katni), analysis by A. B. Searle for Katni Industrial and Cement Co. 3. Flag Staff hill (Katni), analysis by A. C. Macdonald for Katni Industrial & Cement Co. 4. Netarhat (Palamau), analysis Geo. Survey Lab. Calcutta, for Sir H. H. Hayden. 5. Dudmatiapat (Ranchi), analysis Geo. Survey Lab., Calcutta, for C. S. Fox. 6. Rajadera (Ranchi), analysis Geo. Survey Lab., Calcutta, for C. S. Fox. 7. Rupjar (Balaghat), analysis Imperial Institute, London. 8. Tipagarh (Balaghat), analysis Tata & Sons. 9. Panhala fort (Kolhapur), analysis by R. V. Briggs, Calcutta, for Kolhapur State. 10. Radhanagri (Kolhapur), analysis by R. V. Briggs, Calcutta, for Kolhapur State. 11. Kiniya (South of Belgaum), analysis by R. V. Briggs for Tata & Sons. 12. Chandgad (West of Belgaum), analysis by R. V. Briggs for Tata & Sons. 13. Harnai (Ratnagiri), average of two analyses, Geol. Surv. Lab., Calcutta, for C. S. Fox. 14. Chakar (Jammu), analysis said not to be correct by C. S. Middlemiss. 15. Chakar (Jammu), analysis said not to be correct by C. S. Middlemiss.

Table V, are shown on the map of India on page 91, in black dots, while a somewhat poorer grade is marked with black circles. The black crosses indicate possible hydro-electric sites.

The richest area is undoubtedly between Jabalpur and Katni, but this is nearly 600 miles from either Calcutta, Bombay, or the proposed harbour at Vizagapatam. The East Indian Railway passes within a mile or so of all the best occurrences in this tract. There is a coalfield (Umaria) a few miles away, and Bengal coal is obtainable at a moderate price.

The bauxite area of Western Chota-Nagpur is nearest to Calcutta, but requires the westward extension of the Purulia-Ranchi-Lohardaga line of the Bengal-Nagpur Railway for better facilities of transport. Bengal coal would be readily available. There is a great disadvantage in the break of gauge of railway, which will necessitate transhipment in either direction at Purulia.

The bauxite of the Main Pat in Sirguja is nearly a hundred miles from the nearest railway, so that this area is not likely to receive much attention until a railway is constructed to the state. Sirguja (Bisrampur) is a rich rice-producing country and contains a fairly large coalfield.

There are small occurrences of bauxite on the Amarkantak plateau in Rewa State, but as this region, the source of the Nerbada River, is a place of sanctity and pilgrimage, it is certain that the priests would at first not see eye to eye with a mining company. However, the region further west along the southern margin of the uplands of Mandla appears attractive, but requires examination. The distance from a railway, however, increases with more westerly places.

The bauxite occurrences of the Rupjar valley and the Baihar plateau (Tipagarh, etc.) in Balaghat are good, but lie more than 20 miles from the narrow gauge Gondia-Jabalpur branch line of the Bengal-Nagpur Railway. A tramway for transporting the large stocks of manganese ore near Laughor and Samnapur has long been projected. When this line is made the bauxite could be brought to the site of the proposed Uskal hydro-electric station near Bhaweli. Balaghat lies nearly half-way between Calcutta and Bombay, and the nearest coalfields are in the Pench valley in the Chindawra district and the Wardha valley in the Chanda district.

The Satara district in the Bombay Presidency has so far proved disappointing, but owing to the low silica percentage some of the low-grade laterite of Panchgani, Mahableshwar, and the Yeruli tracts could

be worked if transport facilities were better. There are large areas of this district further south which may contain good bauxite, but in the neighbourhood of the Koyna Valley and the site of the proposed gigantic hydro-electric works, there is no bauxite that is suitable for present processes.

There is a small quantity of excellent bauxite at Panhala in the Kolhapur district, and a much bigger occurrence of workable bauxite near Radhanagri, north of the road leading from Kolhapur city to the Phonda Pass. There is also a possible hydro-electric site near the Pass. The nearest railway is Kolhapur, 30 miles away, and coal would have to come from the Singareni collieries of Hyderabad. However, as the railways largely use wood fuel, it is possible the same fuel or perhaps oil may be available for an alumina factory.

The bauxites of Belgaum are the most attractive in Western India. The occurrences are individually small and widely scattered, and without increased railway facilities most of the places would have to depend on cart and motor transport. The question of coal is nearly the same as in Kolhapur. Marmagoa via Londa is the nearest port for Belgaum.

In the north of the Ratnagiri district, close to the coast near Harnai, there is a possible area of workable bauxite. It has a characteristic vermicular structure, consisting of irregular tubes filled with cream-coloured bauxite in a red matrix of ferruginous matter. The analysis of the whole averages 52% alumina, 14% ferric oxide, 3% silica, 2·5% titanium oxide, and the remainder combined water, moisture, and traces of other impurities. This region would be the nearest occurrence of bauxite to the Koyna valley hydro-electric station at Chiplun.

The Jammu bauxite has already received serious consideration from the Kashmir Durbar, owing to its proximity to a possible hydro-electric site, and the availability of coal of Tertiary age. The upper 4 ft. of this bauxite is said to be workable, but it passes downward into highly siliceous material somewhat similar to the bauxite of County Antrim. The area is rather inaccessible, but lies on a proposed railway alignment, which had been under consideration before the discovery of the bauxite by Mr. C. S. Middlemiss, a retired member of the Geological Survey of India.

Bauxite of good quality also occurs in the north of the Madras Presidency and in Kalahandi State. This is at present an almost impossible tract, but the Bengal-Nagpur Railway have surveyed and propose to construct a railway from Raipur, in the Central Provinces, through part of this country to connect with the Madras line near Vizagapatam. The area has not been properly examined, but should the quantities be attractive there will be no difficulty, when the railway is built, in taking the bauxite to the coast at a fairly cheap price.

(3) Possible Production of Alumina in India.—The process at present commonly employed, both in Europe and America, for the manufacture of alumina from bauxite is known as the Bayer process. (See *Aluminium*, by G. Mortimer, 1919, pp. 22–23.) Briefly it is as follows : The bauxite is crushed and ground to pass a 50 to 100 mesh screen. If the ore contains appreciable percentages of organic matter or combined water it is previously calcined at a temperature not exceeding 400° C. The finely ground material, to which a little lime has been added in the grinding if appreciable percentages of silica are present, is then mixed with a measured quantity of caustic soda solution (sp. gr. 1·45), and well stirred. The mixture is then run into steam-jacketed autoclaves, also provided with stirrers. In these autoclaves the fluid is thoroughly digested until with the heat that has been applied by the steam the pressure inside is raised to above 70 lb. per square inch. At this stage all the alumina is converted into soluble sodium aluminate, while the ferric oxide remains insoluble. The liquor from the autoclave is now blown out by its own pressure into large tanks, and there diluted (sp. gr. 1·23) with washings from previous filtrations. After further stirring in these tanks the liquid is passed through filter-presses in which the insolubles, ferric oxide, etc., are removed and the filtrate pumped into enormous deep tanks. In these the clarified liquid is agitated with revolving paddles and chains and a small quantity of hydrate of alumina is added to assist the precipitation of aluminium hydrate. When the precipitation is considered complete the liquid is forced through further filter-presses. In these the hydrate of alumina is obtained as a white granular powder. The filtrate containing the soda is thickened in special evaporators and used again. The hydrate of alumina is next calcined in a reverberatory furnace at a temperature of about 1,000° C.

to obtain the anhydride. The whole plant is elaborate and expensive. There are, as may be imagined, many precautions to be observed to prevent waste, and great experience is necessary for the successful working of the plant. Very little of the caustic soda is lost if the bauxite is properly corrected, and the ferric oxide sludge obtained in the first set of filters could be used as an iron ore or as a paint material.

The price of bauxite at Marseilles is quoted in *The Mining Journal* at £2 per ton for ore containing 60% Al_2O_3. The price of coal used as fuel in the various works may be taken at roughly 30s. per ton, and the market value of the alumina varies from £20 to £25 per ton for the hydrate and £30 to £40 per ton for the anhydride. Mortimer estimates 2 tons of French bauxite as required for the production of 1 ton of calcined alumina.

From the table of imports (Table IV) it appears that no alumina is imported by India, and that the chief salt is aluminium sulphate. In deciding the question of an alumina factory, this aspect of the case requires careful consideration. Calcined alumina will either have to be exported or a demand created. Hydrate of alumina could be used in the preparation of the sulphate and other purposes in India.

In the following remarks it is not possible, owing to the fluctuations of trade and prices, to give more than a brief outline of the several examples taken. It would require an exhaustive examination of freights, etc., quite beyond the scope of this paper.

Jabalpur. — The Katni area in the Jabalpur district is situated in the heart of India. Here bauxite averaging 56% Al_2O_3 should be obtainable loaded in trucks at the railway station at 4·8 rupees to 6 rupees (about 10s.) per ton. Good Bengal coal, at the same place, costs about 13 rupees per ton, and a poorer quality coal from Umaria is available at approximately seven rupees per ton. Also, owing to the high percentage of combined water in the Katni bauxite, about 25%, compared with roughly 10% in the French ore, it is likely that $2\frac{1}{2}$ to 3 tons of bauxite will be necessary for the production of 1 ton of calcined alumina. The problem is therefore a mathematical one, involving railway freights. For foreign export it may be best to rail the bauxite to the Bengal coalfield, or, when the new East Indian line eastward from Katni through the Sone Valley and the Karanpura coalfields to Asansole is completed, to the Karanpura coalfield, and there purify the bauxite and export from the port of Calcutta. For purposes of reduction to aluminium in India it may be best to establish alumina works at Katni and rail the purified material northward through Amballa to the great hydro-electric station, which is contemplated in connexion with the colossal irrigation dam (at Bahkhra) on the river Sutlej above Rupar. It is estimated that if consumers are available this power station can develop 300,000 electrical horse-power when fully completed. It is a perfect site in every way, and power should be available as cheaply as in average European stations. The whole question with regard to the Katni bauxite, therefore, turns on the question of railway freights. The special goods freights on most Indian railways for coal varies from a maximum of about $\frac{1}{3}$ pies per maund ($\frac{3}{4}$d. per ton) to a minimum of $\frac{1}{10}$ pies per maund (about $\frac{1}{4}$d. per ton) up to distances of 300 miles, and is half this for distances greater than 500 miles.

Ranchi.—Western Chota-Nagpur is not so difficult of solution. Bauxite (Al_2O_3 from 50 to 55%) should be available at Lohardaga railway station at from 7 rupees to 14 rupees (say 10s. to 20s.) per ton, the nearer bauxite of Dudmatiapat being very much cheaper than that of Rajadera until the railway, as contemplated, is extended westward. Although freight calculations may be slightly in favour of bringing coal to Lohardaga, there is no question of doubt that the many other facilities will be favourable to an alumina works being established at Purilia or Asansole, if the existing transhipment difficulties at Purulia can be made cheaper. The price of Bengal coal in the Jherria field is about 6 rupees per ton.

Balaghat.—The present cost of bringing the Baihar plateau bauxite to the railway renders the area unattractive. But if the tramway is made it should be possible to get the raw material (50 to 55% Al_2O_3) to Gondia station on the main line of the Bengal Nagpur railway at about 10 rupees to 12 rupees (say, £1) per ton. Coal from the Pench valley (Chindwara) and the Wardha Valley (Chanda) is available at Gondia at about 8 rupees to 9 rupees per ton, and Bengal coal coats about 14 rupees per ton. An alumina factory at Gondia would be in direct touch, although over great distances, with Calcutta, Bombay, and, when the

Raipur-Vizagapatam line is completed, with Vizagapatam.

Belgaum.—Owing to the unfavourable location of the Chandgad area the Kiniya and Nauga bauxite would alone be used for some years. This material with Al_2O_3 from 50 to 55% should be available at Belgaum or at Desur station at from 5 rupees to 7 rupees (say, 10s.) per ton. Sea-borne Bengal coal would be available at Belgaum for about 27 rupees per ton and Singarenni coal (Hyderabad) at about 14 rupees per ton. A slight calcination, not exceeding 400° C., may be considered in the question of economy for freight to Marmagoa, at which port the alumina factory would perhaps be best established for foreign export.

Ratnagiri.—The bauxite of Harnai occurs practically on the coast and a quality averaging 45 to 50% Al_2O_3 should be available in stacks on the coast for 2 rupees to 3 rupees (say, 5s.) per ton. Bengal coal would cost less than the sea-borne coal in Bombay, say, 20 rupees to 25 rupees per ton, and English coal may be procurable at a reasonable price, say, 40 rupees per ton. This area, if the bauxite occurs in sufficient quantity, would be attractive in many ways. Although it has no harbour, both the bauxite and coal could be taken down the coast to Jaigad, where Tata & Sons contemplate a harbour and large chemical works in connexion with their enormous Koyna Valley hydro-electric scheme. The Koyna Valley lies inland about 40 miles from Harnai, and Jaigad is about the same distance to the south.

Kashmir.—The bauxite in Jammu occurs in close proximity to outcrops of Tertiary coal, as well as to a good hydro-electric power site. If the bauxite is considered suitable for reduction there is little doubt that an alumina factory will be established. An alumina factory alone, unless used in conjunction with a plant for the manufacture of aluminium sulphate, would find a very serious competitor in the Bengal coalfield in questions of export. Large supplies of aluminium sulphate are imported into India for various purposes and the imports are increasing.

In my opinion, however, it should be possible to manufacture alumina, provided there is a demand for it, as cheaply as in Europe, if the production is on a sufficiently large scale. Given increased transport facilities and railway concessions regarding freight, alumina made at Katni, Purulia, or Gondia, should be available f.o.b. Calcutta at a reasonable price for export to markets on the Indian ocean sea-board. An alumina factory at Marmagoa or Jaigad on the western coast of India would have equal advantages. The question is one of demand and large-scale production.

There is one other aspect of this case, that is the production of pure alumina as a by-product by the Serpek process for the fixation of nitrogen by bauxite as nitride of alumina and the subsequent manufacture of fertilizers, nitric acid, ammonia, etc., with release of the alumina. This process would give cheaper bauxite, but, again, it is a question of demand.

(4) Possibility of Manufacturing Aluminium in India.—It is well-known that almost all the aluminium of commerce is obtained in some simple form of electric furnace (the Hall-Heroult), using 8,000 to 20,000 amperes at a low voltage (5 to 8 volts). It is a high-temperature electrolytic process, in which the electric current serves not only to maintain the bath in a molten condition, but also for the deposition of the molten aluminium at the cathode. Alumina (pure anhydride) is dissolved in molten cryolite. When a low voltage current is passed through this solution the alumina is separated into aluminium and oxygen, the metal sinks to the cathode, and the oxygen combines with the carbon of the anodes to form carbonic oxide, which at once burns. The cryolite theoretically should remain unaffected and the whole process appears wonderfully simple. In practice there are many pitfalls, and an enormous amount of care is necessary in the control and management of the plant. (See *Aluminium*, by G. Mortimer, 1919, p. 29–40). The furnaces can be worked at a temperature of 915° C., with about 5% of alumina in solution; the melting point of cryolite is about 1,000° C., and the melting point of a solution with 20% alumina is about the same temperature (1,015° C.), so that an excess or diminution of alumina tends to diminish the economy of working. Further the cryolite is always decomposed in normal working, that is between 6 and 7 volts, and fresh material has to be added from time to time. The consumption of the carbon electrodes constitute a large part of the expenditure, as they are made of the purest carbon (petroleum coke with tar for a binding material). Next there is the danger that the molten aluminium may float to the surface of the bath, short-circuit the furnace, and

catch fire, burning to alumina again. This possibility arises from the closeness of the specific gravities of the substances used, as seen below :—

	Solid	Fused.
Commercial aluminium...........	2·66	2·54
Commercial Greenland cryolite	2·92	2·08
Commercial Greenland cryolite saturated with alumina	2·90	2·35

The margin in such a furnace evolving gas is obviously exceedingly small. It is customary, however, to add a flux, usually aluminium fluoride, which decreases the sp. gr. of the solution to 2·14, lowers the melting temperature to about 800° C., and allows the bath to dissolve 10% more alumina. The average yield of metal is 1 lb. for 2 lb. of alumina. The consumption of the carbon electrodes, at about £15 a ton, is from 1 to 3 lb. of carbon per lb. of the metal obtained. The losses in cryolite and flux average ¼ lb. per lb. of aluminium produced. The efficiency of the furnaces average 90 to 95%, but taking into account stoppages, mishaps, etc., the industrial efficiency is placed by Mortimer at from 50 to 85%. The enormous current used necessitates cheap electrical power as a *sine qua non.* Further a large-scale production is almost certainly more economical than a small output. The manufacture of cheap electrodes of good quality requires consideration, as the impurities in the electrode, silica, ferric oxide, etc., go into the metal and cannot be subsequently removed. Most of the cryolite comes from mines in Greenland, but an artificial cryolite is now available. The market price for cryolite in the United Kingdom is £56 per ton, and this material would have to be imported into India.

Now the two big hydro-electric projects, which could put aside 100,000 e.h.p. for a reduction works, are those of the Koyna Valley hydro-electric scheme in the Bombay Presidency and the Sutlej River hydro-electric project in the Punjab. There are many other sites in India (see Preliminary Report on the Water Power Resources of India by the Hydro-electric Survey of India), but these two have been investigated and will be built; they, however, require consumers. The Sutlej River project would possibly only attract the manufacturers of alumina at Katni, and requires careful investigation. The Koyna Valley scheme should prove suitable for the reduction of alumina made from the bauxite of Harnai, Kolhapur, and Belgaum. The power should be cheap enough, and I believe details are available, but probably require modification in view of the steady decrease in the cost of materials and overseas freight.

The question of Kashmir stands by itself. Bauxite, coal, and electric power should be obtainable cheaply, and if a company can be started there is every reason to expect a profitable production of aluminium. The markets of Northern India, especially the Punjab and the North-West Frontier, could easily be captured if there is no flaw in the quality of the bauxite or the coal and the cheapness of the hydro-electric supply. Even here assuming that everything is suitable, the question of erection and management becomes important. Can the authorities do it under their own control or guarantee the profits of a company for a given number of years, or will a firm take the whole risk for special concessions regarding labour, transport, and coal ?

The question of aluminium production in India is a matter which, assuming that it is possible, as I think it is, depends on the demand. The Indian imports of aluminium are not large, compared with the present production, for instance, of the British Aluminium Company. (See Table III and list of firms and their outputs for 1920.) There is little doubt that the bright silver-grey colour and remarkable lightness of articles made of aluminium are discussed with pride by their owners in far away jungle villages and remote mountain hamlets, but the metal is too expensive for the poorer classes in India. The present price of aluminium in the United Kingdom is £120 per ton, home and foreign export. The average wage of the working man at home is from 25s. to 85s. a week. In India the average wage is less than £10 a year. Although the present may be called the Aluminium Age in Europe and America, it is not so in India, and cannot be till aluminium is one-sixth its present price. It is difficult for the Indian, among the uneducated classes, to understand, without being carefully warned, that this wonderful metal, said to be immune from all kinds of acids, etc., would be corroded by the common salt he uses to give taste to his simple food.

(5) Other Uses of Indian Bauxite.—It has already been intimated that the purification of bauxite to alumina, both as the hydrate and anhydride, is possible and that the production of aluminium should be

commercially practicable. In both these instances, however, the demand in India at the present price of aluminium does not appear to be large enough to justify the erection of works, unless some of the production was to be exported, or until the steel foundries, chemical plants, glass works, munition factories, engineering companies, etc., which are developing in India, absorbed the output for the various needs as flux in steel melting, in the manufacture of aluminium sulphate, special glassware, for making the explosive ammonal, and the production of aluminium wire, sheets, tubing, alloys, etc.

The bauxite of Western Chota-Nagpur should prove useful as a refractory material to the industrial region about Asansole and Singhbhum. There are important firebrick companies in this area, but they do not appear to have included bauxite brick in their list of manufactured products. Such bricks if well made would be vary hard, and could be used as a fire-proof material for the building of banks and other repositories of important documents. Fused bauxite in the manufacture of abrasives could be made at several of the small sites of hydro-electric power, and as the industrial activity of the country grows this material must find an increasing market.

The use of raw, even ferruginous, bauxite (that is laterite) for the treatment of animal sewage has not been tried, but there are theoretical grounds for believing that powdered bauxite would be very effective in precipitating, in a harmless condition, the dangerous constituents of sewage.

Bauxite for the purification of petroleum and other organic fluids, though required from time to time, is not likely to be a real market, owing to the fact that the bauxite in the filters can be used over and over again by simply calcining it when inert.

There are numerous smaller uses for both the crude ore and the refined alumina from the metalling of roads to the manufacture of synthetic rubies and sapphires. But perhaps the greatest use, and the one most likely to influence the world's market and opinion of India's progress, would be the manufacture of fertilizers on an enormous scale by the Serpek process. By this means the irrigation schemes in North-West India would be materially assisted in the production of grain and other necessities of life. Nitric acid and ammonia would be available for the numerous processes which require these chemicals, and cheap alumina would be obtained as a by-product to the raw bauxite, which was utilized in the fixation of the atmospheric nitrogen. This alumina could then be used as in Europe for the manufacture of wrought and unwrought aluminium goods, and the various other uses already detailed. These are possibilities which are also probable, and when India had attained the accomplishment of these her position as a member in the Commonwealth of Nations constituting the British Empire would not only be one of importance, but rather of great dignity.

BOOK REVIEWS

The Iron-Ore Resources of Europe. By MAX ROESLER. Bulletin 706, United States Geological Survey.

This small work of 152 pages is of particular interest at the present moment, as it gives a clear and concise account of the available supplies of iron ore in the principal countries of Europe, as seen through American eyes. It may be said at the outset that the work has been very well done, perhaps even surprisingly well done, considering the disabilities under which the author has worked. He evidently has no personal knowledge of the deposits that he describes, and has been forced to rely upon existing literature, with the further drawback that he is quite unable to estimate the relative reliability of the various sources from which his information is derived. Accuracy of detail cannot be hoped for under such conditions, and it is perhaps a matter of surprise, not that there are mistakes, but that there are so few serious ones. To take one example, almost at random, the existence of magnetite in Portugal is not even mentioned, and the author is evidently quite unaware of the fact that nearly all the deposits in Central Alemtejo down to Evora consist of lenticular masses of magnetite, and that practically the whole of the iron ore exported from Portugal to Great Britain consisted of this mineral. Perhaps the most serious shortcoming is the entire omission of any reference whatever to the excellent series of monographs on British Iron Ores contained in the Special Reports on the Mineral Resources of Great Britain, published among the Memoirs of the Geological Survey, which certainly constitute the most complete and authoritative account of British iron ores. They are not even mentioned in the elaborate bibliography attached to the volume, though it is really difficult to understand how they came to be overlooked. Mr. Roesler would be well advised to study them carefully.

Unquestionably, however, the main interest of the present work lies in the introductory portion. The author commences very properly with a definition of what he understands by iron ore, in the following terms: "The term 'ore' as here used, means an aggregate of iron-bearing minerals that is now commercially valuable or that may reasonably be expected to be valuable in time of need." This definition is obviously faulty, inasmuch as it makes the decision whether a given deposit is or is not an iron ore depend upon extrinsic rather than intrinsic conditions. Thus a mass of, say, hematite in the heart of Africa would not, according to the definition, be classed as an iron ore, and it is even very doubtful whether it would include to-day our own Coal Measure ironstones, although these were at one time practically the only iron ores worked in this country, and provided the foundation upon which the great British iron industry was built up. In reading Mr. Roesler's book, his definition must, however, be accepted and well borne in mind, because it accounts for the differences between certain of his estimates and those of other writers who have adopted a different (and possibly more logical) definition.

Another matter that is, to say the least of it, open to question, is Mr. Roesler's classification. He divides all iron ore deposits into two main classes, which he calls respectively "deep-seated" and "surficial." In the former class he places only those deposits directly connected with igneous rock, (*a*) gabbroic and (*b*) granitic. He would hence describe such deposits as our Cumberland and Lancashire red hematites as surficial, a phrase that no geologist who knows these deposits would endorse. They are replacement deposits along fault or contact planes in the Carboniferous Limestone, and according to what is perhaps the most generally accepted theory, the ferruginous solutions that gave rise to their formation were derived by leaching from the overlying Triassic rocks. It is surely an abuse of language to apply the term surficial to deposits produced under such conditions.

Particular interest attaches at the moment to Mr. Roesler's discussion of the economic situation, which commences with the following important statement: "The iron industry in Europe labours under several disadvantages, as compared with the industry in the United States. Perhaps the greatest of these disadvantages is the low output of iron per man employed in mining ore." He supplements this statement by figures showing the tonnage of iron in ore mined per man per year, of which the most interesting to us are the following: United States 590, Lorraine 376, United Kingdom 230. If it is assumed that the percentages of iron in the ores mined in these three countries are respectively 55, 35, and 30, the tonnages of ore mined per man per annum would come out at 1,073, 1,074, and 767. It is not clear whether these figures refer to pre-war or post-war conditions; at the moment the iron miners of Lorraine are doing quite excellent work. The writer of this review was recently in a Lorraine mine, where a miner and labourer were working together in a 20 ft. wide stall; they had to blast out the ore, load it into wagons, and tram these over a hundred yards by hand, and the output of the two men was 36 tons per 8 hour shift, or 18 tons per man! This was a normal and not an exceptional output. Contrast our Cleveland mines, where the natural conditions are somewhat similar, though it may be granted not quite as favourable to the miner, but where men are considered to be doing well if they produce at the rate of 6 tons per man per day. No doubt the steady preaching by the labour leaders for so many years of the "ca'canny" principle has much to answer for, but this is not the only reason why we are lagging behind in the race. The greatest proportion by far of the ironstone blasted underground in Britain is still to-day got by hand-drilling, and there is not in the whole country one single mechanical underground ore-loading appliance in use; it is doubtful whether one has even been experimented with. Unquestionably, Mr. Roesler is right when he advocates "the further use of labour-saving devices." Some of our difficulties are possibly due to the absurd system of legislation that groups ironstone mines with coal mines and imposes upon the use of electricity in the former many of the restrictions which the possible presence of firedamp and coal dust renders necessary in the latter. Be the causes, however, what they may, the obvious conclusion is that the output of ore per miner must be increased if we are to maintain our position as iron-producers; this is absolutely the only way in which the relatively lower grade of our iron ores can be counterbalanced.

Mr. Roesler is on far less secure ground when he says that "A further disadvantage in Europe appears to be the comparatively low blast-furnace output," for it is by no means clear that this is wholly a disadvantage. He goes on to say: "If greater output per unit is a measure of efficiency, Europe falls far below the United States," but, as far as the blast-furnace is concerned, it may be doubted whether his criterion is a sound one. Take a large works, producing annually a million tons of pig iron, or, say, 3,000 tons per day. An American works would probably supply this output with five 600-ton furnaces, an English works with ten 300-ton furnaces. The capital cost of the latter may be somewhat greater than that of the former, but not very much, because, apart from the furnaces themselves, the equipment, the blowing capacity, stove capacity, etc., would be the same in either case. The American works would require at least one large furnace as a stand-by, the English works a small one. If a furnace is temporarily stopped the American output falls off by 20%, the English by only 10%. The American method of intensive driving is harder on the furnace-linings and upon the whole furnace, and results in shorter lives and more frequent repairs. The English method may demand a little more labour, but in modern blast-furnace practice labour requirements are reduced to a minimum, and labour forms so small an item in the cost of producing pig iron that this difference is negligible. Upon the whole, there is much to be said in favour of the moderate-sized unit. Mr. Roesler would have been on surer ground had he condemned the old-world adherence to old-fashioned furnace plants, hand-fed furnaces, imperfect utilization of waste gases, and similar out-of-date wasteful survivals. It is a fact that open-topped blast-furnaces are still to be found in existence in this country! If it were for nothing else, Mr. Roesler's work is of great value to us in this country, because it enables us to compare our standing in the iron industry with that of other competing nations, and affords us some indication of where our chief weaknesses lie. HENRY LOUIS.

A Manual of Determinative Mineralogy. By CHARLES H. WARREN, Ph.D. Small octavo, 163 pages. Price 10s. New York and London: McGraw-Hill Book Company.

This little book originated as printed notes for the author's course in mineralogy. It is therefore not surprising to find it especially clear in the description of methods and manipulation. The first chapter deals with the use of the blow-pipe, closed and open tubes, and other apparatus. The treatment is eminently practical and includes experiments to test the beginner's skill with each piece of apparatus. Barite is misprinted on page 9. The second chapter describes simple tests for the elements, which are, on the whole, fairly complete. It is, however, a pity that the zinc reduction test for cassiterite was not described here, or later in the book. The third chapter gives lists of useful reactions. The fourth and last chapter deals with the determination of minerals and includes a series of systematic determinative tables, which are well arranged and will enable the student who works systematically through them to identify all the commoner minerals. The student is referred to more advanced works for microscopic methods, the importance of which is insisted on. The book can be recommended to the beginner as an excellent introduction to determinative mineralogy. It is well got up, with clear type, and is small enough for the pocket.

E. H. DAVISON.

The Analysis of Coal and its By-products. By S. ROY ILLINGWORTH, M.Sc., A.R.C.Sc. With foreword by Sir ROBERT ROBERTSON, K.B.E., F.R.S. Price 21s. net. London: The Colliery Guardian Co., Ltd.

One of the most favourable impressions created by a perusal of this book is its completeness. Many volumes dealing with specialized chemical analysis are notorious for the amount of cross reference necessary both in the text and to other standard works; the annoyance and waste of time caused by such inquiries can only be appreciated by those who have to undertake complex technical research, and it is most gratifying to find in a book such as this that the subject matter is essentially adequate.

The methods described are the latest. Where older methods are quoted much useful constructive criticism is given in justification of the adoption of more precise manipulations, many of these being modifications suggested by the personal researches of the author.

No work on coal analysis would be complete without some reference to the investigations carried out by the United States Bureau of Mines, many of whose methods and results have become classical. The author quotes the Bureau practice with regard to the representative sampling of coal prior to analysis, by no means an insignificant operation either technically or commercially. The ultimate analytical determinations are then discussed in detail, and conform very broadly to the procedure recommended for coal analysis by the American Society for Testing Materials and the American Chemical Society, who have endeavoured to standardize methods of evaluation of all types of naturally occurring hydrocarbons. The author devotes much space to the initial estimations of moisture, ash, volatile matter, and fixed carbon, while the ultimate analysis of coal, involving the determination of carbon, hydrogen, sulphur, and nitrogen, receives ample treatment.

We are glad to note that the subject of coke is not passed over cursorily, as is so frequently the case in books written about coal; too little attention has been paid in the past to the production of suitable metallurgical coke of uniform quality for specific operations; obviously as a check to the nature of the product, analysis of the coke is just as essential as the analysis of the coal from which it is derived, and the author's conclusions drawn from research on the various types of coal giving rise to coke, demonstrate the intrinsic importance of the matter. Such coke analysis takes into account physical properties such as hardness, strength, and porosity in addition to the necessary chemical estimations of sulphur, phosphorus, ash, etc.

The book includes chapters on the analysis of crude coal-tar, the estimation of light oil and its products, the analysis of ammonia liquor and ammonium salts, gas analysis, calorimetry, and the action of solvents on coal. In the last chapter a brief explanation of the use of flash-point apparatus and the Redwood viscometer (as applied to oils) is given, while the five appendices contain some useful information relevant to the technical examination of coal. The book is illustrated with diagrams, and some important graphs are included; the price, however, is somewhat excessive, and may impede that wide circulation which the volume undoubtedly merits.

H. B. Milner.

Oil Shales. By H. B. Cronshaw, B.A., Ph.D., A.R.S.M. Paper covers, 110 pages. Price 5s. net. London: John Murray and the Imperial Institute.

A general knowledge of the existence of adequate oil-shale resources throughout the world has hitherto served to ameliorate the many pessimistic reports current as to the ultimate exhaustion of supplies of natural petroleum. Until, however, one had had the opportunity of reading this monograph, with its comprehensive account of those resources, it was a little difficult to appreciate the true extent and widespread distribution of such deposits, quite apart from their great potential value. Alderson, in his book on the oil-shale industry (reviewed in the Magazine for January, 1921) gives a graphic account of the "mountains" of oil shale awaiting development in the United States, but the information concerning other countries is not so complete; we therefore welcome Dr. Cronshaw's latest work, not so much as a contribution to oil-shale literature, but rather as a significant indication of the far-reaching developments to be expected when these deposits become better known and more closely investigated.

With Alderson, we perceive unique possibilities in the development of the oil-shale industry, though it is useless to wait until necessity (in the shape of shortage of supplies of petroleum) drives us to contemplate other sources of petroleum and petroleum products. The present volume shows conclusively that it will not be for the want of raw material that development will be tardy; economic and technical difficulties may obtain at the moment, but they are neither permanent nor insurmountable.

In this place it is unnecessary to dilate on the descriptions given in the volume of such well-known shale occurrences as those of Scotland, France, Canada, and the United States; but the paragraphs dealing with prospects in South Africa, Bulgaria, Esthonia, Yugo-Slavia, China, Chile, and Uruguay invite brief comment. The Ermelo and Wakkerstroom districts of the Transvaal, and the Utrecht district of Natal, have attracted considerable attention of late, largely owing to Wagner's optimistic reports on the possibilities of establishing a successful oil-shale industry in the Union, more especially in view of the absence of natural petroleum and the high prices ruling for oil fuel generally. The Bulgarian deposits are less known; they are located at Bresnik, Radomir, Popovtzi, Kazanlik, and at Sirbinovo, where the shales have yielded 54 gallons of oil per ton on test. In Esthonia the resources have been estimated at 40,000 million tons of shale, and 61 gallons of oil per ton have been obtained. The Alexinatz shales in Yugo-Slavia have been tested in Scotland with encouraging results, though no commercial developments have as yet matured. The Chinese deposits are located at Fushun, Manchuria, and the shales are associated with bitminous coals of Tertiary age; the Japanese are developing the industry here and an estimate of 1,300 million tons of raw material is mentioned. The Chile deposits of shale have recently been investigated, but the details are at present lacking; up to 62 gallons of oil per ton have been obtained, and the prospects are alleged to be favourable. In Uruguay near Melo City, oil shale has been discovered, and mining is to be undertaken shortly; geologically speaking, this department offers great possibilities in this respect, and it is likely that more will be heard concerning these resources.

Apart from the descriptive sections of the monograph, there is an introductory chapter dealing with the occurrences, characters, and uses of oil shale; this chapter is good, as far as it goes, but certain vital points have not been sufficiently emphasized. For instance, one of the greatest troubles to contend with in the production of shale oil is the designing of a retort capable of giving the maximum efficiency with a particular shale. The type of retort used successfully in Scotland is entirely unsatisfactory when used for certain other shales, and in this fact we have one of the chief reasons for dilatory development of the industry in many countries. Again, the ammonia by-products, so valuable in the Scottish industry, are almost a negligible quantity in countries where climatic conditions preclude the necessity of employing artificial fertilizers.

The book is complete with a map of the oil-shale deposits of the world and a short bibliography. H. B. MILNER.

NEWS LETTERS

SOUTH AFRICA

January 13.

COLLIERY STRIKE.—As a direct result of the policy of compromise and concession, under which it has been the unfailing policy during the past seven years to meet all South African labour demands, the Transvaal mining industry is now faced with a crisis of uncommon gravity. The strike of the coal-miners, commencing at the New Year, became the signal for a general mine labour upheaval, and on January 10 all productive work ceased on the gold mines, in the chief power stations, and the engineering workshops on the Rand.

The clear-cut issue of the coal strike has now passed into the background. The reduction of the high colliery wage of 30s. per shift to 25s., demanded by present market conditions, could not have been made the basis of a general strike, with any hope of popular approval. But the colliery owners, in giving notice of the inevitable reduction, took the unusually bold course of determining for themselves the measure of the wage reduction essential under the changing industrial conditions. Instead of naming primarily a bigger wage reduction, conferring, negotiating, arbitrating, compromising, arriving eventually at a figure first thought of, and revealing to the world the power of the South African Industrial Federation as collective bargainers, the controllers of the collieries attempted to control.

Actually, the magnitude of this wage reduction has had little or nothing to do with the strike. Had the reduction been only 1s. per shift, the coal strike would have occurred. The issue is one of principle only. The question now being settled at enormous cost and inconvenience to the country is whether it is permissible for an industry to calculate the wages and working conditions it can afford to offer under the quickly changing conditions of to-day, or whether an industry should call upon the unions to put forward a schedule they are prepared to accept, and wait upon their pleasure for the favour of relief until the industrial ills are beyond recovery.

The coal strike, nominally based on the "ultimatum" of this 17% decrease in wages, would have led automatically and rapidly to the closing down of all Rand mines. Thus the South African Industrial Federation found itself forced to bring forward precipitately a number of other issues, and to call a general strike immediately on wider and more complex grounds, rather than to see a ludicrous colliery dispute the cause of general mine stoppage and of unemployment on the Rand gold mines.

WIDE STRIKE ISSUES.—The new points at issue in the trial of strength may be best covered by considering the remarkable ballot-paper by which the feelings of Union members were roused, rather than ascertained, on January 3. The paper was as follows: "The following ultimatums have been delivered by the Coal Owners, Chamber of Mines, Victoria Falls Power Company, and Engineers' and Founders' Association:—

(1) Refusal of the Coal Owners to arbitrate on the proposed reduction of wages.

(2) Chamber of Mines threat to substitute cheap black labour for white.

(3) Alteration of underground working conditions (contracts system).

(4) Refusal of V.F.P. Company to continue to negotiate with the workers on a basic rate of wages.

(5) The threatened breaking agreement and reduction of wages by the Engineers' and Founders' Association.

The Executives of the South African Industrial Federation and the Unions concerned recommend members to vote in favour of a strike.

Are you prepared to strike until these ultimatums are withdrawn?

Yes. No."

With the case presented in this manner, it is not surprising that the rank and file —wholly out of touch with conditions in the outside world—should have voted for a strike. The marvel is that 1,068 men voted against it, out of the 12,111 voters who returned their papers.

CHAMBER OF MINES ATTITUDE.—For three years the Rand gold mines have been enjoying a large measure of prosperity, owing to the gold premium. The steady decrease in this premium and the increasing importance of reduced working costs to allow the poorer mines to continue operations, prompted a drastic reorganization of underground conditions. Proposals put forward by the Chamber of Mines were discussed in November and December. A conference was further fixed for January 11. But some action has been long overdue, and only by the Chamber giving notice that changes would be effected on February 1 could any hope of progress be gained. The changes, broadly, would lead to economy through the gradual decrease in the ratio of white to coloured employees. At present the ratio is 1 : 8½. By establishing an ultimate maximum of 1 : 11, and allowing semi-skilled work now classified as white man's work to be genuinely the coloured man's (as it is often in practice), so long as this ratio is not exceeded, would undoubtedly give prospects of renewed life to the languishing mines.

The alteration of the contracts system, under which, for years, the "big cheque" has been won, out of all proportion to the efficiency of services rendered, would be a minor gain, but should be dealt with in the general reorganization.

CONDUCT OF STRIKE.—It is dangerous to predict the course of events in a centre of strife like Johannesburg. Both sides appear determined to see the fight through. The strikers may hope for Government intervention, that is, for arbitration that may leave them no better off, but save their leaders from the humiliation of defeat. The Chamber may be prepared to accept enormous financial losses rather than continue the past policy of concession and of extravagance in payment for inefficient work. Out of the evil good must come.

On January 9 General Smuts said that the Government would "draw a ring about both parties, and take an impartial view, do its best to maintain law and order, and let the two parties fight it out."

The country expects more of the Government than this. Only the Government can establish the facts of the situation fully, and making its voice heard above the din, publish its verdict for the guidance of that popular opinion, by which, in the long run, all labour issues are now decided.

DIAMOND-MINING STAGNATION.—While the gold and coal mining industries are full of men who can work but won't, the diamond mines have their burden of hundreds who would work but cannot. The Premier mine still works one shift. The Jagersfontein continues relief work, thereby incurring the wrath of the Unions, who object to their members receiving less that standard wages, although employment is given solely to reduce distress. At Kimberley, the situation is the most serious. After big retrenchments in 1920 and 1921, the heaviest blow fell at the beginning of this month, when the De Beers Company were forced to put off between 600 and 700 men, men who, for the most part, have had long specialized service with the company, and are little qualified to gain a footing in other, already overcrowded fields. The necessity for drastic retrenchment has been manifest for so long that the mining community has been preparing itself for bad times and endeavouring to establish local industries and relief works to provide employment. The most interesting proposal is the construction of a branch line from Kimberley to Kuruman, via Barkly West and Borrel's Kop, which would serve an important section of the alluvial diamond diggings. The Railway Administration's recent deficits prompt the Government to searching investigations as to the payability of this branch line, but the ill times that have befallen the "diamond city" should justify at least a generously optimistic view of the line's chances of profitable operation when the district is active once more.

TORONTO

January 9.

PORCUPINE.—For some time a reduction in the wage scale of the gold camps has been under consideration. While a general decrease of wages has taken place in practically all other lines of industry, including silver mining, the rate of pay at Porcupine and Kirkland Lake has remained as high as during the era of inflated prices. Beginning with the New Year, the Hollinger Consolidated, Dome Mines, and McIntyre have announced a reduction of 6 cents per hour, or approximately 10%. This will still leave the rate about 25 cents per day higher than that paid in the Cobalt district. The reduced operating cost will enable the companies to treat much low-grade ore hitherto left behind.

The Hollinger is steadily increasing its output, and last month established a new record by the treatment of approximately 4,700 tons in twenty-four hours. The company during 1921 disbursed a total of $3,126,000 in dividends, its profits during the last half of the year far exceeding dividend requirements.

The Dome Mines treated about 30,000 tons of ore in November, the mill-heads averaging $8·40 per ton, and operating costs being about $3·50 per ton. The profits for the month are estimated at approximately $145,000. The company is negotiating for the purchase of the Foley-O'Brien, adjoining the Dome Extension section on the north-east. Work done on this property was disappointing, but the geological structure is favourable, as the porphyry rocks found on the Dome extend into the Foley-O'Brien. The main shaft of the Dome is nearing a depth of 1,450 ft., at which level the occurrence of high-grade ore-bodies has been proved by diamond-drilling.

At the McIntyre two new veins each about 8 ft. wide and carrying about $7 in gold per ton, have been cross-cut on the 1,375 ft. level. The new unit of the mill, of 250 ton capacity, is in process of installation. Further enlargements of the milling equipment are held in abeyance until the company can be assured of a sufficient supply of power.

It is reported that rich ore has been encountered at the Davidson mine in the lower workings, and that diamond-drilling has indicated a new ore-body on the 500 ft. level. Power shortage has recently caused a temporary stoppage of operations. The shaft of the Porcupine Paymaster will be lowered from 200 to 400 ft., where an ore-body 98 ft. in width should be cross-cut. The shareholders of the Porcupine Vipond-North Thompson have authorized the sale of 475,000 shares of treasury stock at 15 cents per share to raise funds for continuing development. Diamond-drilling operations on the Rochester by the Nipissing of Cobalt, which has an option on the property, have resulted satisfactorily. Five holes out of six showed encouraging gold content.

KIRKLAND LAKE.—The first report of the Kirkland Lake Proprietary (1919), covering the period from the date of incorporation in October, 1919, to June 30 last, indicates that the gold-producing stage is likely to be reached shortly. The Lake Shore during November treated 1,810 tons of ore, with a recovery of $54,343, being an average of $30·02 per ton. Some very rich ore has come from development work at the 600 ft. level, where the ore-bodies are more heavily mineralized than on the 400 ft. level The vein has been cut at the 400 ft. level of the Bidgood, where it shows a width of 20 ft., but the gold content is lower than on the 300 ft. level. The Queen Lebel has done 4,000 ft. of trenching, and opened up six veins, the most important of which yields assays varying from $1 to $33 in gold and 37 oz. in silver. At the Wright-Hargreaves work is in progress on four levels, the gold content of the ore increasing with depth. Official figures show that during the third quarter of 1921 the mill handled a total of

12,533 tons of ore with a production of $177,420. The shaft is being put down from 400 ft. to deeper levels. The shaft of the Comfort Kirkland has been sunk to a depth of 150 ft., at which level a number of small veins have been encountered. The operations of the new mill of the Ontario Kirkland have been delayed by breaks in the machinery. Development is being steadily carried on.

COBALT.—The La Rose Consolidated found 1921 the most profitable year since 1916, an advance estimate of profits being about $150,000. Its University property is yielding rich ore at the 90 ft. level. The winze on the Violet is being put down to the 600 ft. level to open up the ore-body, from which much good ore has been extracted on the 530 ft. level. The Nipissing maintains a heavy production. During November the company mined ore of an estimated net value of $251,253. The annual report of the Coniagas for the year ended October 31 shows an output of 1,301,515 oz. of silver from the treatment of 113,279 tons of ore. Profits were $422,258, and operating costs 33·55 cents per oz., as compared with 48·98 during the previous year. The Right of Way mine has been unwatered preparatory to the resumption of mining by the Right of Way Syndicate. At the Oxford Cobalt the vein on the 75 ft. level shows a silver content of 60 oz. to the ton in addition to cobalt. The Victory is opening up a strong vein at a depth of 185 ft.

ELBOW LAKE.—A new gold camp at Elbow Lake in Northern Manitoba has attracted many prospectors, and several hundred claims have been staked. The Hollinger, of Porcupine, has taken an option on the Murray claims, on which the original discovery was made, the price being stated at $150,000. A force of twenty-five men has been sent in to begin immediate development. Other locations are changing hands at high figures, Toronto and Montreal capitalists having become interested.

VANCOUVER, B.C.

January 11.

THE CONSOLIDATED COMPANY.—Considering the depressed state of the lead and zinc markets throughout nearly the whole of last year, the Consolidated Mining and Smelting Company made a really remarkable production at its plant at Trail. The company handled 411,612 tons of ore, and produced metals to the value of $6,694,865. In 1920 the company handled 383,112 tons, and the production was valued at $7,326,925. The following are the details of the production, those for 1920 being given for comparison :—

	1920	1921
Gold, oz. . . .	42,636	51,037
Silver, oz. . .	1,097,930	1,173,890
Copper, lb. . .	4,501,594	3,556,517
Lead, lb. . . .	26,474,652	57,051,110
Zinc, lb. . . .	36,995,394	51,131,270

For the greater part of the year the company carried an enormous stock of both lead and zinc, but during the last three months large sales were made in Europe and Asia, and by the close of the year the stock of lead had been reduced to a normal working quantity while the stock of zinc had been greatly diminished. With the exception of about 10,000 tons, 3,888 tons of which came from mines in the State of Washington, the whole of the ore containing the lead and zinc came from the company's Sullivan mine, at Kimberley, while practically the whole of the gold came from the company's Centre Star and War Eagle mines at Rossland.

A number of metallurgical improvements were made at the smelter during the year. The concentration of the Sullivan mine ore, which is a compact sulphide, containing blende, marmatite, galena, pyrrhotite, and pyrite, with about 6% of gangue, was so improved that hand-sorting at the mine was abandoned and the separation of the minerals made entirely at the concentrator, high-grade lead and zinc concentrates being obtained. Improvement was made in the roasting of the zinc concentrate, the formation of difficultly-soluble ferrates of zinc, which has harassed the successful operation of the plant for some time, being now in the main avoided. The result has been a much improved extraction of zinc, while the residue, after the bulk of the zinc has been extracted, is more easily treated in the lead furnaces for the extraction of lead and silver. The rod-mill has been completed, and has a capacity of 8 tons of brass or copper rods per 8-hour shift, and the capacity of the copper refinery has been increased to 70 tons daily. Owing to a scarcity of ore, little has been done in the copper department of the smelter.

The plans for future development include increasing the capacity of the power plant at Bonnington Falls, which is operated by the West Kootenay Power and Light Company, a subsidiary of the Consolidated, the erection of a 2,500 ton concentrating plant at the Sullivan mine, the greater part of which will be made in the machine shops at Trail, the remodelling of the present concentrator at Trail, which now is used for the Sullivan ore, to treat the ores from the company's Rossland mines; and the finding of copper ore to supply the copper department at the smelter. The company owns mines on Vancouver Island on which large bodies of low-grade ore have been developed, but before these can be profitably operated concentrating plants will have to be erected, and probably this will be done, unless satisfactory arrangements can be made with the Canada Copper Corporation for the reopening of its mine at Copper Mountain. The last is the more desirable, as 11 million tons of 1·7% copper ore has been developed at the mine, and a 2,000 ton plant has been completed at Allenby, 4 miles from the mine.

Premier Mine.—The Premier Gold Mining Company's tramway was put into operation during the last weeks of the year, and gradually is being tuned up to capacity. It is 11½ miles long, and is said to be the longest aerial tramway on the continent. There are 250 buckets, each with a capacity of 7 cu. ft., or about 1 ton, and the travelling speed is 6 miles per hour. The discharging terminal is an elaborate three-storey building, containing bunker capacity for 1,500 tons of ore and warehouse space for 1,000 tons of concentrate, also offices and apartments for attendants. There is an elaborate system of belt-conveyors for loading ore and concentrate directly on to steamers. The tramway was constructed by the Riblet Tramway Company, of Spokane, Washington. Although the concentrating and cyanide plants were not completed until last autumn, the Premier shipped more than one million ounces of silver and some 25,000 ounces of gold last year. This, however, does not by any means represent the output of the mine, as there is a considerable accumulation of high-grade ore and concentrate at the mine awaiting shipment. To facilitate the movement of this the company has its teams and tractors transporting ore and concentrate over the snow to the wharf at Stewart, and returning with heavy machinery that would be too great a tax for the tramway. The output during the present year is likely to be sensational.

LETTERS TO THE EDITOR

A Disclaimer

The Editor:

Sir—It has come to my knowledge that Mr. C. S. Richardson, residing at Diamantina, Brazil, has been writing to various people in this country in connexion with properties and concessions at the Rio Jequitinhonha, using this company's name and the names of its officials as references. This has been done entirely without authority.

C. F. W. Kup,
Managing Director,
St. John del Rey Mining Company, Ltd.
Finsbury House, London, E.C. 2.
February 3.

False "Mining Engineers"

The Editor:

Sir—I venture to ask the hospitality of your columns to refer to the case, recently dealt with at the Old Bailey, of Joseph Aspinall, described as a "mining engineer", whose conduct was characterized by the prosecuting counsel as a "huge swindle from the start". I am directed to point out that the defendant was not in any way connected with either of the Institutions representing the two branches of the mining engineering profession, and he was not known to them as a "mining engineer".

The Press would perform a great service to the mining industry as well as to the investing public if it would impress upon its readers the fact that every man who describes himself as a "mining engineer" or "mining expert" is not necessarily a qualified mining engineer. Investors and employers would be well advised to satisfy themselves as to the professional qualifications and credentials of such persons before trusting them. Great harm is done to the mining industry and injustice to the mining engineering profession by the omission to take these elementary precautions.

The whole profession will be grateful to you, Sir, if you will give publicity to this protest and warning.

C. McDermid,
Secretary,
The Institution of Mining and Metallurgy,
and
The Institution of Mining Engineers.
225, City Road, E.C. 1.
February 7.

MAGNETIC SEPARATOR LITIGATION

A noteworthy victory has been won in the German Patent Appeal Court by English patentees against the firm of Fried. Krupp. This action arose out of the opposition on the part of Krupps to the application for a patent made by Messrs. H. H. Thompson and A. E. Davies, of the Rapid Magnetting Co., Ltd., of Birmingham, and proceedings before the examiners and the court have dragged on from 1917. The patent concerned was connected with an electro-magnetic separator for separating feebly magnetic ores from other ores, and from each other, by means of a high intensity magnetic separator for which patents have already been granted in England, France, and many other countries. This separator has the entirely new and characteristic feature that by a slight inclination of the separating armatures or discs it is possible to raise separately and simultaneously, on one and the same armature, two magnetic minerals of different magnetic permeability, as, for instance, ilmenite and monazite, and to deposit them as separate products. Another novel and most useful feature is that the adjustment of the separating armatures can be performed while the machine is in motion, so that they can be quickly and accurately set to give the best results in use for the particular material under treatment.

The opposition Krupps raised in 1917 was based on an allegation that the invention was included in an old patent which they controlled, and, further, that any features which distinguished the invention from the old patent were not workable, and the advantages claimed could not be reaped in actual use. Krupps' opposition was successful in the examination department, but the English inventors appealed, and after the hearing of the appeal the higher court decided that there was a patentable invention. They required, however, a practical demonstration in Berlin of the machine to prove that it was commercially possible to do what the inventors claimed. The English inventors accordingly dispatched a machine to the German Patent Office, and went over to Berlin in November last, and by suitable inclination of the separating armature, as claimed, they carried out the simultaneous separation of two distinct magnetic ores from a mixture of two magnetic ores and a non-magnetic substance. After the experiments were concluded the decision of the tribunal was reserved. Toward the end of last month the judgment was issued annulling the decision of the lower court and allowing the patent.

This judgment states: "The contention supporting the refusal decision of the court below that a useful separation effect was not attainable with the applicants' separator has been disproved by the demonstration of November 5, 1921.

"The demonstrated separation in which out of a mixture of one non-magnetic and two different magnetic materials all three ingredients were divided was considered to prove the practical usefulness of the machine.

"That the claim that the applicants' machine was the subject of the old patent 228,913 cannot be conceded because the characteristic features, namely, the placing of the rotating armature at an inclination to the direction of movement of the conveyor, and the adjustability of this armature, are not contained in that patent."

The English patentees are to be congratulated on winning their case in the German court, and also on demonstrating before this court the efficacy of their invention.

PERSONAL

M. Aymard has been awarded one of the Frecheville Research Scholarships at the Royal School of Mines. His subject will be connected with the crystallization of amorphous silica.

Dr. J. Mackintosh Bell is here from Ontario.

John A. Bevan is back from Roumania.

G. W. Campion has left for West Africa.

George Chalmers, general manager for the St. John del Rey Company, has been home for a serious internal operation, but is expecting to return to the mine this month.

Stanley Christopherson, one of the directors of the Consolidated Gold Fields of South Africa, has been elected one of the deputy chairmen of the London Joint City and Midland Bank.

L. Maurice Cockerell has returned from visits to California and Mexico.

John V. N. Dorr is expected from the United States.

John Duncan is expected from Portugal.

Rowland C. Feilding left for Italy on February 9.

J. G. Foley is expected shortly from Nigeria.

R. T. Hancock is here from Ontario.

James Hocking has left London for Paignton, Devon, where his address will be Tregantle, Bellevue Road.

J. P. Hodgson has been appointed manager of the mining operations of the Phelps Dodge Corporation in the Morenci-Clifton-Metcalf district, including those of the Arizona Copper Company

(*Continued on next page.*)

recently absorbed. NORMAN CARMICHAEL, hitherto manager of the Arizona Copper Co., becomes consulting engineer to the Corporation for this district, and will have his office in New York.

H. C. G. KINLOCH has left for West Africa to take charge of the development of the Appollonia Gold Fields' new properties in the Kwahu district.

NEWTON B. KNOX is paying a visit to the Phœnicia tin mines, Noya, Spain.

CHARLES LEACH has left for Nigeria to take over the management of the Rayfield properties.

F. MOUAT has left for New Zealand.

Sir LIONEL PHILLIPS returned from South Africa last month.

A. BASIL REECE has gone to Quechisla, Bolivia.

A. V. REIS was described in our editorial last month on the Genesis of Iron Compounds as "of the Tharsis Sulphur and Copper Co." Mr. Reis was with this company from 1912 to 1919, but resigned in the latter year to take the position of mines' superintendent at the Cueva de la Mora mine of the Huelva Copper and Sulphur Company.

D. RENOUF has gone to Jos, Nigeria.

C. H. STEWART is to make an examination of the Aroa copper mines for the South American Copper Syndicate.

D. A. THOMSON has left for West Africa.

H. H. WATSON has left for Nigeria.

H. WHITTINGHAM left on February 3 for Ontario to join the staff of the Keeley silver mine, South Lorrain.

W. R. WRIGHT has left for Mexico.

C. Y. YANG is here from China investigating the flotation process as applied to coal cleaning.

A. H. CULLEN, secretary of the Tronoh and a number of other Malayan companies, died on January 23 at the age of 59 after a long and painful illness. He was well known in the City as an accountant of the highest skill and probity.

W. R. LAWSON, one of London's oldest and best known financial journalists, died on January 16, aged 82. He was with the *Financial News* in the early days and afterwards was editor of the *Financial Times*. His contributions to the financial Press continued to a few days before his death. He was a member of the Stock Exchange for the last twenty-six years.

Dr. R. LOGAN JACK died in Sydney on October 29 last, at the age of 76. He was a Scotsman by birth and went to Queensland in 1872, where he served as Government Geologist for over twenty years. Subsequently he went to China, and did much pioneer work in the exploration of the inland provinces. His book, *The Back Blocks of China*, embodies his experiences in that part of the world, and will always be known as one of the great books of travel.

SIR FRANCIS H. BARKER, a director of Vickers, Ltd., died on January 28. He had an intimate knowledge of Russia, Turkey, and the Near East, being born at Smyrna, and beginning his business career at his father's bank at Constantinople, subsequently becoming private secretary to Lord D'Abernon (then Sir Edgar Vincent), director-general of the Imperial Ottoman Bank. In 1899 he was appointed manager of the Parsons Foreign Patents Company, and in this capacity was highly successful in introducing the Parsons steam turbine on the Continent and elsewhere. In recent years his influence as a director of Vickers, Ltd., was universally recognized among engineers.

TRADE PARAGRAPHS

The NATIONAL ENGINEERS' SUPPLY CO. (LIVERPOOL), LTD., of 26, Preesons Row, Liverpool, send us refills for their calendar, which they instituted last year.

BOVING & CO., LTD., of 56, Kingsway, London, W.C. 2, have secured a contract from the New Zealand Government for the supply of power-plant for the Managhac hydro-electric scheme. The plant to be supplied consists of five Pelton wheels, three of 8,000 h.p. each, and two of 4,000 h.p.

EDGAR ALLEN & CO., LTD., of the Imperial Steel Works, Sheffield, send us their *Edgar Allen News* for February. This gives information relating to the firm's turbo-pulverizer for producing powdered coal for use in heating steel for the forge; subsequently the gases of combustion go to the boilers for steam-raising purposes.

THE WESTINGHOUSE ELECTRIC AND MANUFACTURING CO., of East Pittsburgh, Pennsylvania, send us a leaflet describing the application of their arc-welding system to repairs and reclamation. They also announce that their C. G. Schluedenberg has left New York on an extended visit to Chile, Peru, Uruguay, Paraguay, and Brazil.

R. & J. BECK, LTD., of 68, Cornhill, London, E.C. 3, have put on the market their "Standard London Petrological Microscope," which they have recently designed for the use of students. Its construction embodies some of the recommendations of a Committee of the British Science Guild, which devoted much time to the consideration of this subject in 1916.

MINERALS CONCENTRATION, LTD., of 4, London Wall Buildings, London, E.C. 2. have issued a pamphlet describing Mr. W. W. Richardson's rotary concentrator, which is applicable to the treatment of platinum, gold, and tin gravels, and also to the washing of iron ores. We hope to be able to give particulars of the principle and performance of this concentrating machine in an early issue.

The METROPOLITAN-VICKERS ELECTRICAL CO., LTD., of Trafford Park, Manchester, announce that they have received the contract for the electrification of the Natal railway from Durban to Glencoe and Vryheid. There is much heavy coal and other traffic on this line, and the gradients are severe. The cost of the work is about £1,000,000, and the Manchester company secured the contract in face of much American and Continental competition.

The GENERAL ELECTRIC CO., LTD., of Magnet House, Kingsway, London, W.C. 2, send us particulars of an installation consisting of a 100 h.p. Witton motor, 2,200 volts, 50 cycles, 1,500 r.p.m., with flame-proof slip-ring cover, driving a centrifugal pump placed underground at Taylor's Navigation Colliery, Nantgarw, South Wales. An excellent photograph was taken of this installation by the light of the firm's 500-watt Osram gas-filled lamp. The firm also send us particulars of the new show rooms at their Cardiff office, where everything electrical required for mining purposes is to be seen.

The GENERAL ENGINEERING COMPANY, of Salt Lake City and New York, send us their new Metallurgical Bulletin. J. M. Callow is the president of this company, and with him are associated Ernest Gayford, James W. Neill, and others. Their works at Salt Lake City are adapted for the testing of ores for concentration and metallurgical treatment, and the company have designed and built many important treatment plants in the United States. Mr. Callow is well known for his flotation cell and screen. The Bulletin in addition to giving information relating to the firm's business, contains a great variety of technical details, useful to ore-dressers and metallurgists.

The WILFLEY COMPANY, LTD., of Salisbury House, London, E.C. 2, are putting on the market an improved form of Wilfley table, embodying a number of refinements in design and construction, having for their object the reduction of power required, adaptation to a greater variety of types of material, greater variation of speed and stroke, etc., all calculated to obtain a better recovery at a lower cost. The following are the chief points: Speed variation of 200 to 350 r.p.m.; delicacy and flexibility of adjustment; perfect and permanent alignment; stroke range from ¼ in. to 1½ in.; self-contained head motion running in oil bath; completely adjustable while running; takes only ¾ h.p. actual; handles down to the finest ground product; gives a higher extraction of mineral contents. We hope to give further particulars and drawings in an early issue.

NOBEL INDUSTRIES, LTD., of Nobel House, London, S.W. 1, will be represented at the British Industries Fair, Castle Bromwich, Birmingham, by their sporting ammunition, and also by the products of one of their subsidiaries, the Necol Industrial Collodions, Ltd. Specimens will be on view illustrating the uses of the various Necol products for the metal trades and the engineering and woodworking trades. With regard to the metal trades, the Necol products which should appeal to this class are principally the transparent lacquers. These are water-white lacquers, and can be supplied for application by brushing, dipping, or spraying. These transparent lacquers give a practically invisible coating on all kinds of metal ware, and are cold or air drying, that is to say, no stoving is required. Black enamels for general metal work, optical work, etc., are also supplied in a full range from matt to glossy. The company also make a wood finish which is used as a substitute for French polish. The celluloid wood finishes are now being adopted largely for furniture work. For the engineering and woodworking trades the company produce a novel material in Necol plastic wood. This product is a mouldable material, with a consistency of thick paste which hardens on exposure to the air into a tough, solid, waterproof substance. It should prove extremely valuable for the engineers' pattern-maker, as it is capable, when set hard of being worked with the usual tools in every way similar to wood. Fillets either straight, or in the most intricate curves, can be modelled very easily. For joinery, cabinet making, and general woodwork Necol plastic wood will be found to be excellent for filling in shakes in timber shrinkage, openings at joints, etc. It will stand nails and tacks, will take stain, polish, and varnish, and is unaffected by water or heat.

The DORR COMPANY, of New York (London office: 16, South Street, E.C. 2) send us a booklet which describes their laboratory and testing-plant at Westport, Connecticut. This booklet is entitled "Testing that Pays Dividends." The Dorr system, starting in one branch of metallurgy, has rapidly extended its circle of applications, and the company are always keen to try all new suggestions. This laboratory has been built for the purpose of testing such possible applications and working out schemes of treatment. The company have specialized for years in problems involving the handling or treatment of finely divided solids suspended in liquids. This may mean continuous settling, classification or sizing, agitation or mixing, the separation and recovery of valuable solids or valuable solutions, the elimination of waste products or solutions, the clarification of waste waters for re-use or to prevent stream or sewer pollution, the treatment or neutralization of factory wastes or municipal sewage, or an almost unlimited number of other applications of the same basic principles. In every case the fundamental Dorr improvement lies in substitution of a continuous, automatic, inexpensive operation for the old, costly intermittent methods. The services now offered by the company are: The determination of the commercial value of industrial, chemical, and metallurgical processes; the examination of mines and mineral deposits, and the management of their operation; the selection of equipment and determination of methods of operation for the manufacture and treatment of various products, as well as the demonstration of the performance of these methods on a full or semi-commercial scale; the development of processes for the disposal of trade wastes and for the recovery of valuable products from them; the design of complete chemical, industrial, or metallurgical plants or of certain portions of them; the supervision of the construction and initial operation of plants designed by the company, as well as their management.

METAL MARKETS

COPPER.—Values on the standard copper market in London during January receded slowly and steadily; the loss on the month was, however, slight. Various factors operated to cause the depression, among which the continued firmness displayed by the sterling exchange in America was not the least. Demand from consumers was dull, as was but natural in view of the quietness of inquiry for manufactured products. Meanwhile the price of electrolytic in the United States slipped back somewhat, and the London market was deprived of the cheerful reports which had been previously coming from the other side of the Atlantic. The interest taken by the Continent was not very pronounced, but moderate quantities of metal were, nevertheless, absorbed by European countries. The immediate future of the London market depends largely on the American news and the course of the sterling-dollar exchange. As has already been announced, various mines are re-starting in the United States. This resumption is understood to have been undertaken in order to avoid a shortage of supplies for domestic consumption; but this seems rather paradoxical as a large block of metal is held in America, ostensibly for export, but which nevertheless would be sufficient to meet home needs for some time to come.

Average price of cash standard copper: January, 1922, £65 4s. 9d.; December, 1921, £66 15s. 4d.; January, 1921, £71 1s. 4d.; December, 1920, £75 16s. 8d.

Daily London Metal Prices: Official Closing

Copper, Lead, Zinc, and Tin per Long Ton

Copper

	Standard Cash	Standard (3 mos.)	Electrolytic	Wire Bars	Best Selected
Jan.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.
10	65 7 6 to 65 10 0	66 5 0 to 66 7 6	73 0 0 to 74 0 0	73 0 0 to 74 0 0	68 0 0 to 70 0 0
11	65 5 0 to 65 7 6	66 0 0 to 66 2 6	73 0 0 to 74 0 0	73 0 0 to 74 0 0	— —
12	65 7 6 to 65 10 0	66 5 0 to 66 10 0	73 0 0 to 74 0 0	73 0 0 to 74 0 0	— —
13	65 10 0 to 65 12 6	66 5 0 to 66 7 6	73 0 0 to 74 0 0	73 0 0 to 74 0 0	68 0 0 to 70 0 0
16	65 12 6 to 65 15 0	66 7 6 to 66 10 0	73 0 0 to 74 0 0	73 0 0 to 74 0 0	— —
17	65 2 6 to 65 5 0	65 17 6 to 66 0 0	72 10 0 to 73 10 0	72 10 0 to 73 10 0	67 0 0 to 69 0 0
18	64 7 6 to 64 12 6	65 5 0 to 65 7 6	72 0 0 to 73 0 0	72 0 0 to 73 0 0	— —
19	65 5 0 to 65 7 6	66 2 6 to 66 5 0	72 0 0 to 73 0 0	72 0 0 to 73 0 0	— —
20	65 0 0 to 65 2 6	65 15 0 to 65 17 6	72 0 0 to 73 0 0	72 0 0 to 73 0 0	67 0 0 to 69 0 0
23	65 0 0 to 65 2 6	65 15 0 to 65 17 6	71 0 0 to 73 0 0	72 15 0 to 73 5 0	— —
24	64 17 6 to 65 0 0	65 12 6 to 65 15 0	71 5 0 to 73 5 0	72 15 0 to 73 5 0	67 0 0 to 69 0 0
25	65 0 0 to 65 2 6	65 15 0 to 65 17 6	71 5 0 to 73 5 0	72 15 0 to 73 5 0	— —
26	64 17 6 to 65 0 0	65 12 6 to 65 15 0	71 5 0 to 73 5 0	72 15 0 to 73 5 0	— —
27	64 10 0 to 64 12 6	65 7 6 to 65 10 0	71 0 0 to 73 0 0	72 10 0 to 73 0 0	66 10 0 to 68 10 0
30	64 10 0 to 64 12 6	65 5 0 to 65 7 6	71 0 0 to 72 10 0	72 0 0 to 72 10 0	— —
31	64 0 0 to 64 2 6	64 15 0 to 64 17 6	71 0 0 to 72 0 0	71 10 0 to 72 0 0	66 0 0 to 68 0 0
Feb.					
1	63 5 0 to 63 7 6	64 2 6 to 64 5 0	70 0 0 to 72 0 0	71 0 0 to 72 0 0	— —
2	62 7 6 to 62 10 0	63 7 6 to 63 10 0	69 0 0 to 71 0 0	70 0 0 to 71 0 0	— —
3	61 12 6 to 61 15 0	62 10 0 to 62 12 6	69 0 0 to 71 0 0	70 0 0 to 71 0 0	65 0 0 to 67 0 0
6	61 10 0 to 61 12 6	62 10 0 to 62 12 6	68 0 0 to 70 0 0	69 0 0 to 70 0 0	—
7	61 7 6 to 61 10 0	62 7 6 to 62 10 0	68 0 0 to 70 0 0	69 0 0 to 70 0 0	65 0 0 to 67 0 0
8	61 10 0 to 61 12 6	62 10 0 to 62 12 6	67 0 0 to 69 0 0	68 0 0 to 69 0 0	— —
9	61 7 6 to 61 10 0	62 5 0 to 62 7 6	67 0 0 to 69 0 0	68 0 0 to 69 0 0	— —

Tin.—The cautious views which we expressed last month when reviewing the upward spurt in prices on the London standard tin market were fully justified during January, when the optimism previously displayed disappeared. Despite occasional rallies, values have been steadily falling, and a loss of nearly £10 was registered during the month. The December statistics, revealing as they did a further increase in visible supplies, did not assist sentiment to remain cheerful, and with home and Continental demand dull, considerable bear selling on 'Change, and reports of free selling in the East, the market assumed a decidedly depressed aspect. The large sales in the East were due to the approach of the Chinese New Year, immediately before which much liquidation usually takes place. America was at times sufficiently attracted by the weak London market to come in as a purchaser, but demand from that quarter still appears to be under normal, despite the activity reported at the American tinplate mills. The outlook seems far from encouraging, although the present price is obviously cheap. A reaction would not be surprising, but at the same time it is difficult to see how the market can assume a really healthy appearance until production and consumption more closely approach each other, and until the stocks held by the authorities in the East cease to be regarded by market interests as a vague menace to stability.

Average price of cash standard tin: January, 1922, £163 3s. 4d.; December, 1921, £169 16s. 10d.; January, 1921, £190 13s. 11d.; December, 1920, £212 11s. 8d.

Lead.—Prices on the London market eased somewhat during the month of January, partly owing to the quietness of trade following the holidays. It was noticeable that arrivals were better than they had been for some time past, fair quantities coming in from Spain, Australia, and Burma. America also featured as a supplier, but the bulk of her shipments were absorbed on the Continent. Consuming demand in the United Kingdom was rather poor, despite reports that manufacturers of lead products were experiencing better trade. Demand from the Continent was less insistent owing to American competition. The shortage of prompt metal was relieved at times during the month, with the result that the backwardation occasionally disappeared altogether; ultimately, however, on holding interests regaining a certain amount of control of the market, it reappeared, broadening indeed to 5s. The position in the United Kingdom has recently undergone considerable change, as stocks are down to almost negligible dimensions, and consumers will doubtless be compelled to buy shipment lead in future if they wish to assure their supplies. There is a likelihood of larger outputs in Mexico, Australia, and Burma, but in some quarters it is believed that should the London price recede further, Spanish producers would restrict production.

Average price of soft pig lead: January, 1922, £23 12s. 2d.; December, 1921, £24 19s. 7d.; January, 1921, £23 12s. 6d.; December, 1920, £24 11s. 10d.

Spelter.—Like other markets on the London Metal Exchange, spelter had a somewhat weak tendency during last month. This came as a surprise in some quarters, as it had been thought that while arrivals continued so restricted, prices were likely to advance rather than recede. Stocks in the United Kingdom were certainly decreasing steadily up to the end of December, and probably the statistics for January may show a further decrease. Nevertheless, arrivals from producing countries have been quite sufficient in view of the comparatively poor consuming demand, and consequently values have fallen away. Belgian makers have not been ostensibly offering to any extent, but despite this, fair quantities of spelter have been coming in from that country, possibly on account of old contracts. Demand from galvanizers has been rather quiet of late. Sentiment has probably been influenced to some extent by expectations of larger arrivals in the future, and doubts as to the ability of consumption to absorb the additional metal. Belgian output is steadily expanding, while, although America may not come out as a seller, Australasian and English

Prices on the London Metal Exchange.
Silver per Standard Ounce; Gold per Fine Ounce.

Lead: Soft Foreign	Lead: English	Zinc (Spelter)	Standard Tin: Cash	Standard Tin: 3 mos.	Silver: Cash	Silver: Forward	Gold	
£ s. d. £ s. d.	£ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	d.	d.	s. d.	Jan.
24 10 0 to 24 5 0	26 0 0	26 15 0 to 27 2 6	165 5 0 to 165 7 6	167 0 0 to 167 5 0	35½	35¼	97 2	10
24 7 6 to 24 5 0	26 0 0	26 10 0 to 26 17 6	165 12 6 to 165 15 0	167 7 6 to 167 10 0	35⅜	35⅛	97 5	11
24 5 0 to 24 0 0	25 15 0	26 10 0 to 26 17 6	167 5 0 to 167 10 0	168 15 0 to 169 0 0	35¼	34⅞	97 3	12
24 2 6 to 24 0 0	25 15 0	26 12 6 to 27 0 0	166 5 0 to 166 10 0	168 0 0 to 168 5 0	35¾	35¼	97 4	13
23 17 6 to 23 15 0	25 10 0	26 10 0 to 26 17 6	165 0 0 to 165 5 0	166 15 0 to 167 0 0	35⅛	35	97 6	16
23 2 6 to 23 2 6	25 0 0	26 2 6 to 26 10 0	163 7 6 to 163 10 0	165 0 0 to 165 5 0	35	34⅞	97 7	17
23 2 6 to 23 2 6	25 0 0	26 7 6 to 26 15 0	163 17 6 to 164 0 0	165 15 0 to 166 0 0	35⅛	35	97 11	18
23 2 6 to 23 2 6	25 0 0	26 5 0 to 26 12 6	163 15 0 to 164 0 0	165 10 0 to 165 15 0	34⅞	34¾	98 0	19
23 5 0 to 23 2 6	25 0 0	26 2 6 to 26 10 0	162 12 6 to 162 17 0	164 5 0 to 164 10 0	34⅞	34⅝	97 6	20
23 0 0 to 22 17 6	24 10 0	26 0 0 to 26 7 6	158 15 0 to 159 0 0	160 5 0 to 160 10 0	34¾	34½	97 9	23
23 2 6 to 23 0 0	24 10 0	25 17 6 to 26 5 0	158 10 0 to 158 15 0	160 0 0 to 160 5 0	35	34⅝	97 7	24
23 2 6 to 23 0 0	24 10 0	25 10 0 to 25 7 6	156 0 0 to 156 5 0	157 15 0 to 158 0 0	35	34⅝	97 6	25
23 2 6 to 23 0 0	24 10 0	25 10 0 to 26 0 0	155 15 0 to 156 0 0	157 10 0 to 157 15 0	35	34½	97 5	26
23 2 6 to 23 0 0	24 10 0	25 12 6 to 26 2 6	157 0 0 to 157 5 0	158 15 0 to 159 0 0	34⅞	34½	97 4	27
23 2 6 to 22 17 6	24 10 0	25 15 0 to 26 2 6	157 10 0 to 157 15 0	159 5 0 to 159 10 0	35⅜	34⅞	97 0	30
22 15 0 to 22 10 0	24 0 0	25 0 0 to 25 10 0	159 10 0 to 159 15 0	161 5 0 to 161 10 0	35¼	34¾	96 6	31
								Feb
22 0 0 to 21 15 0	23 10 0	24 15 0 to 25 5 0	158 10 0 to 158 15 0	160 5 0 to 160 10 0	35⅛	34⅝	96 3	1
21 12 6 to 21 10 0	23 0 0	24 10 0 to 25 0 0	156 0 0 to 156 5 0	157 17 6 to 158 0 0	35⅛	34¾	95 9	2
21 5 0 to 21 5 0	23 0 0	24 2 6 to 24 12 6	154 0 0 to 154 5 0	155 17 6 to 156 0 0	35⅛	34¾	95 8	3
20 17 6 to 20 15 0	22 5 0	24 0 0 to 24 12 6	154 5 0 to 154 10 0	156 5 0 to 156 10 0	34⅝	34¼	95 5	6
21 5 0 to 21 2 6	22 10 0	24 7 6 to 25 0 0	155 15 0 to 156 0 0	157 15 0 to 157 17 6	34⅜	34	95 0	7
21 5 0 to 21 2 6	22 10 0	24 10 0 to 25 5 0	157 5 0 to 157 10 0	159 0 0 to 159 5 0	34⅛	33⅝	94 9	8
21 0 0 to 20 17 6	22 10 0	24 2 6 to 24 17 6	154 5 0 to 154 10 0	156 0 0 to 156 5 0	34⅛	33⅞	95 1	9

production is certain to be a factor in the near future.

Average price of spelter: January, 1922, £26 10s. 2d.; December, 1921, £27 0s. 11d.; January, 1921, £25 15s. 7d.; December, 1920, £28 11s. 6d.

Zinc Dust.—Prices are nominally unaltered as follows: Australian high-grade £50, American 92 to 94% £47 10s., and English 90 to 92% £45 per ton.

Antimony.—The market has been steady, with English regulus priced at £34 to £37 per ton for ordinary brands, and £35 5s. to £39 for special brands. A better inquiry is noticeable for foreign material, which is quoted at £24 10s. in warehouse for home business; for export less is accepted.

Arsenic.—Business is stagnant, with Cornish white nominally quoted at £40 per ton, delivered London.

Bismuth.—The price has been advanced to 9s. per lb.

Cadmium.—A small business is passing at 5s. 9d. to 6s. per lb.

Aluminium.—Domestic makers quote £120 for home and £125 for export, but Scandinavian metal is offered at £87 10s. and German at £92 10s. f.o.b. Continent.

Nickel.—Business is dull. Domestic material is quoted at £175 for both branches of trade, but foreign is obtainable at around £170 per ton.

Cobalt Metal.—Steady at 14s. per lb.

Cobalt Oxides.—A little business is passing at 10s. 9d. per lb. for black and 12s. for grey.

Platinum.—Prices have advanced. Raw is now about £19, and manufactured £21 per oz.

Palladium.—Makers of manufactured material quote £19 10s. per oz., but this is somewhat nominal. We hear of small business in raw around £13 to £14.

Quicksilver.—The market has been quiet, but firmer, the current price being about £11 to £11 10s. per bottle.

Selenium.—The price is lower at 9s. per lb. for powder.

Tellurium.—The price has fallen and there are sellers at 60s. per lb.

Sulphate of Copper.—The price has fallen and the quotation is now £28 per ton for both home and export.

Manganese Ore.—The quotation for Indian ore has kept fairly steady at 1s. 1½d. per unit c.i.f.

Tungsten Ore.—The market is stagnant, with 10s. 6d. per unit c.i.f. Hamburg quoted for 65% WO_3.

Molybdenite.—85% has eased to 27s. 6d. per unit, c.i.f., nominal.

Chrome Ore.—Easy and quiet, with Indian grades priced at £3 15s. to £4 per ton c.i.f.

Silver.—Fluctuations during January were slight, but on balance a rise was registered. Spot bars opened the month on January 3 at 34⅛d., rose to 35½d. on the 9th, fell to 34¾d. on the 21st. and closed on the 31st at 35¼d. Indian buying was the main support of the market, though China also came in as a purchaser at one time.

Graphite.—Values have eased, Madagascar 80 to 90% being now quoted at £18 per ton c.i.f.

Iron and Steel.—The pig iron outlook has assumed a brighter aspect. There has been some renewal of buying both for home and export, with the result that the number of furnaces in blast has been increased. Buyers realize that prices cannot be reduced substantially any further until costs come down, and as Continental competition is out of the running, British producers are at last coming into their own. Early in the month Cleveland quotations were reduced, No. 3 G.M.B. being obtainable at 90s. for either home or export. Hematite has not been quite such a bright market as foundry pig, though a fair amount of business has been passing, but with makers anxious for orders, values have had to give way. East Coast mixed numbers are now quoted at 92s. 6d., but transactions can be put through possibly at less money. In the finished iron and steel trades there has been a marked diminution in the business passing between this country and the Continent, as works on that side cannot offer reasonable delivery, and, as in some instances, prices have been advanced. Makers here, however, have not yet received a fair quota of business and plants are still only partly employed. Official quotations for the home trade remained unchanged throughout the month.

STATISTICS

Production of Gold in the Transvaal.

	Rand	Else-where	Total	Price of
	Oz.	Oz.	Oz.	Gold per oz.
				s. d.
Total, 1920	7,949,038	204,587	8,153,625	—
January, 1921 ...	637,425	14,168	651,593	105 0
February........	543,767	14,370	588,137	103 9
March	656,572	14,551	671,123	103 9
April	665,309	16,073	681,382	103 9
May	671,750	16,026	687,776	103 9
June............	663,383	15,107	678,490	107 6
July	673,475	16,080	689,555	112 6
August..........	695,230	16,296	711,526	111 6
September.......	674,157	16,939	691,096	110 0
October	690,348	17,477	707,825	103 0
November	688,183	16,053	704,236	102 0
December	664,935	16,912	681,847	95 6
Total, 1921......	7,924,534	190,052	8,114,586	—

Natives Employed in the Transvaal Mines.

	Gold mines	Coal mines	Diamond mines	Total
December 31, 1920 ..	159,671	14,263	3,340	176,522
January 31, 1921 ...	165,287	14,541	3,319	183,147
February 28	171,518	14,697	1,612	187,827
March 31	174,364	14,906	1,364	190,634
April 30	172,826	14,908	1,316	189,050
May 31	170,595	14,510	1,302	186,407
June 30	168,152	14,704	1,317	184,173
July 31	166,999	14,688	1,246	182,933
August 31	169,008	14,446	1,207	184,661
September 30	171,912	14,244	1,219	187,375
October 31	175,331	13,936	1,223	190,490
November 30	176,410	13,465	1,217	191,092
December 31........	177,836	13,280	1,224	192,340

Cost and Profit on the Rand.

Compiled from official statistics published by the Transvaal Chamber of Mines.

	Tons milled	Yield per ton	Work'g cost per ton	Work'g profit per ton	Total working profit
		s. d.	s. d.	s. d.	£
Dec., 1920 ...	1,797,970	39 11	26 8	13 3	1,193,672
January, 1921	1,895,235	35 0	26 3	8 9	829,436
February	1,575,320	35 6	28 6	7 0	550,974
March	1,958,730	34 5	26 1	8 4	813,636
April	1,991,815	34 5	25 10	8 7	854,533
May	1,955,357	35 3	26 2	9 1	889,520
June	1,966,249	35 10	25 10	10 0	979,769
July.........	2,010,236	37 2	25 7	11 7	1,163,565
August	2,050,722	37 3	25 4	11 11	1,226,282
September ...	1,997,086	36 8	25 2	11 6	1,151,127
October......	2,041,581	34 4	24 9	9 7	981,597
November ..	2,007,617	34 6	24 9	9 9	978,931

Production of Gold in Rhodesia.

	1919	1920	1921
	£	oz.	oz.
January	211,917	43,428	46,956
February	220,885	44,237	40,816
March	225,808	45,779	31,995
April	213,160	47,090	47,858
May.............	218,057	46,266	48,744
June	214,215	45,054	49,466
July	214,919	46,208	51,564
August	207,339	48,740	53,200
September	223,719	45,471	52,436
October	204,184	47,343	53,424
November	186,462	46,782	53,098
December	158,835	46,190	55,968
Total	2,[illegible]9,498	552,498	591,525

Transvaal Gold Outputs.

	November		December	
	Treated Tons	Yield Oz.	Treated Tons	Yield Oz.
Aurora West..........	10,723	£14,181†	10,550	£13,711*
Brakpan	57,900	23,338	53,000	22,594
City Deep	86,500	34,603	82,500	34,288
Cons. Langlaagte	45,000	£66,692†	43,000	£60,624*
Cons. Main Reef	50,000	17,793	49,800	17,788
Crown Mines..........	171,000	55,758	152,000	44,118
D'rb'nRoodepoortDeep	27,000	8,784	26,000	8,699
East Rand P.M........	124,500	30,243	129,000	32,371
Ferreira Deep	33,100	10,431	18,300	7,148
Geduld..............	46,000	17,363	46,000	17,065
Geldenhuis Deep	48,777	12,941	50,662	13,331
Glynn's Lydenburg ...	3,600	£6,752§	3,920	£7,038‡
Goch	16,500	£18,517†	15,700	£18,302*
Government G.M. Areas	140,000	£319,903†	141,000	£286,488*
Kleinfontein	48,600	13,123	48,200	13,393
Knight Central........	30,000	6,707	30,000	6,883
Langlaagte Estate	45,000	£69,160†	45,000	£64,702*
Luipaard's Vlei	18,760	£20,360†	20,715	£20,004*
Meyer & Charlton	14,600	£43,076†	14,500	£40,505*
Modderfontein, New ..	108,000	50,391	105,000	48,441
Modderfontein B	59,000	30,095	56,000	28,640
Modderfontein Deep ..	43,300	23,728	41,600	22,997
Modderfontein East....	24,600	10,366	24,200	10,499
New Unified	11,700	£13,142†	11,900	£12,151*
Nourse	45,800	15,527	45,800	14,858
Primrose	22,500	£24,621†	22,200	£24,459*
Randfontein Central ..	121,000	£179,327†	118,500	£161,339*
Robinson.............	39,500	8,112	38,600	8,772
Robinson Deep	60,500	20,040	62,000	18,897
Roodepoort United ...	17,650	£18,785†	17,100	£17,181*
Rose Deep	55,000	13,879	52,600	13,109
Simmer & Jack	60,000	14,632	59,200	14,203
Springs	45,000	18,913	42,000	18,813
Sub Nigel	10,400	5,994	10,700	6,511
Transvaal G.M. Estates.	14,330	£21,906§	16,090	£22,876‡
Van Ryn	32,600	£46,883†	32,750	£46,308*
Van Ryn Deep	55,400	£150,826†	54,600	£132,174*
Village Deep	51,100	16,216	48,000	15,422
West Rand Consolidated	33,000	£44,878†	33,000	£44,071*
Witw'tersr'nd (Knights)	42,700	£55,237†	45,200	£53,187*
Witwatersrand Deep ..	35,000	10,036	35,380	10,393
Wolhuter.............	31,200	7,673	32,500	7,757

* Gold at £4 15s. 6d. per oz. † £5 2s. per oz. ‡ £4 13s. 6d. per oz.
§ £5 Cs. 3d. per oz.

Rhodesian Gold Outputs.

	November.		December.	
	Tons	Oz.	Tons	Oz.
Cam & Motor	14,200	4,970	15,000	5,172
Falcon	15,671	2,882*	15,501	2,913‖
Gaika	4,002	1,489	4,158	1,492
Globe & Phœnix	6,139	5,970	6,102	7,142
Jumbo	1,450	500	1,350	471
London & Rhodesian ..	3,283	£4,301	3,932	£3,847
Lonely Reef	5,200	5,024	5,100	4,849
Planet-Arcturus	—	—	5,930	2,604
Rezende	5,850	2,845	6,000	2,853
Rhodesia G.M. & I. ..	—	—	227	304
Shamva	60,100	£39,692‡	59,100	£38,617§
Transvaal & Rhodesian	1,610	£5,345†	1,500	£4,800†

* Also 259 tons copper. † At par. ‖ Also 275 tons copper.
§ Gold at £4 16s. per oz. ‡ Gold at £4 17s. Cd. per oz.

West African Gold Outputs.

	November		December	
	Tons	Oz.	Tons	Oz.
Abbontiakoon	7,100	£11,571*	7,150	£14,132*
Abosso	6,303	2,566	5,800	2,348
Ashanti Goldfields	7,503	6,943	7,534	8,358
Obbuassi	693	£2,714†	550	£2,445†
Prestea Block A........	6,764	£10,704*	7,547	£11,123*
Taquah	3,320	2,116	3,190	2,030

* At par. † Including premium.

West Australian Gold Statistics.—Par Values.

	Reported for Export Oz.	Delivered to Mint Oz.	Total Oz.	Par Value £
April, 1921	607	46,602	47,209	200,635
May	474	47,638	51,503	217,495
June	153	28,194	28,347	120,410
July	1,641	44,917	46,558	197,774
August	110	51,731	51,841	220,205
September	380	50,728	51,108	217,092
October	1,910	51,286	53,196	225,959
November	156	46,429	46,585	197,879
December	451	53,348	53,799	228,522
January, 1922	329	37,851	38,180	162,177

Australian Gold Outputs.

1921	West Australia oz.	Victoria oz.	Queensland oz.	New South Wales £
January	51,458	4,587	4,582	20,463
February	27,557	10,940	9,046	21,575
March	47,886	12,383	6,690	24,344
April	47,273	5,954	2,591	34,101
May	48,113	10,280	2,077	15,356
June	28,347	10,431	1,602	11,640
July	46,558	5,528	1,531	16,416
August	51,842	8,941	1,413	15,946
September	51,108	9,113	2,601	16,942
October	53,197	8,496	1,595	17,451
November	46,586	—	1,356	10,248
December	—	—	—	12,688
Total	499,925	85,993	35,084	217,370

Australasian Gold Outputs.

	November		December	
	Tons	Value £	Tons	Value £
Associated G.M. (W.A.)	6,171	8,346‖	4,733	7,067‖
Blackwater (N.Z.)	3,401	6,717*	2,533	4,981*
Gold'n Horseshoe (W.A)	10,284	5,540‡	7,248	4,155‡
Grt Boulder Pro. (W.A.)	9,214	[illegible]	6,425	19,275‖
Ivanhoe (W.A.)	15,341	5,902‡	11,385	4,094‡
Lake View & Star (W.A.)	7,252	14,014‖	4,995	12,812‖
Oroya Links (W.A.)	1,592	14,453‖†	1,163	8,432‖†
South Kalgurli (W.A.)	[illegible]	[illegible]	5,740	9,740‖
Waihi (N.Z.)	14,638	4,395‡ 31,311§	14,547	[illegible]‡ 50,571§
„ Grand Junc'n (N.Z.)	6,320	1,391‡ 4,859§	5,150	1,529‡ 4,898§

* Including premium ; † Including royalties ; ‡ Oz. gold § Oz. silver ; ‖ At par.

Miscellaneous Gold and Silver Outputs.

	November		December.	
	Tons	Value £	Tons	Value £
Brit. Plat. & Gold (C'lbia)	—	[illegible]	—	—
El Oro (Mexico)	31,500	171,000†	32,000	167,000†
Esperanza (Mexico)	—	415e	—	[illegible]
Frontino & Bolivia (C'lbia)	2,240	7,429	2,300	7,998
Keeley Silver (Canada)	—	[illegible]	—	37,000s
Mexico El Oro (Mexico)	13,000	183,700†	13,130	180,100†
Mining Corp. of Canada	—	133,575s	—	—
Oriental Cons. (Korea)	17,816	101,940†	—	[illegible]
Ouro Preto (Brazil)	7,100	2,224	7,200	2,600‖
Plym'th Cons. (Calif'rnia	7,900	7,757*	8,400	10,164*
St. John del Rey (Brazil)	—	45,000*	—	45,000*
Santa Gertrudis (Mexico)	32,022	11,311‡	34,077	12,624‡
Tomboy (Colorado)	17,900	76,000†	18,000	79,000†

* At par. † U.S. Dollars. ‡ Profit, gold and silver. ‖ Oz. gold. *p* Oz. platinum and gold. *s* Oz. silver. *e* Profit in dollars.

Pato (Colombia): 24 days to January 2, $13,879 from 154,375 cu. yd.; 16 days to January 18, $10,0[illegible] from [illegible] cu. yd.

Nechi (Colombia): 17 days to January 1, $[illegible] from 112,828 cu. yd.

Indian Gold Outputs.

	November		December	
	Tons Treated	Fine Ounces	Tons Treated	Fine Ounces
Balaghat	3,200	2,371	3,300	2,666
Champion Reef	11,616	4,934	11,697	4,907
Mysore	17,569	10,506	17,599	10,514
North Anantapur	550	644	550	642
Nundydroog	8,813	5,362	9,048	5,357
Ooregum	12,900	8,476	12,900	8,492

Production of Gold in India.

	1917	1918	1919	1920	1921
	Oz.	Oz.	Oz.	Oz.	Oz.
January	44,718	41,420	38,184	39,073	34,028
February	42,566	40,787	36,384	38,872	32,529
March	44,617	41,719	[illegible]	38,760	32,576
April	43,726	41,504	38,248	37,307	32,363
May	42,901	40,889	38,608	38,191	32,656
June	42,924	41,264	38,359	37,864	32,207
July	42,273	40,229	38,549	37,129	32,278
August	42,591	40,496	37,850	37,375	32,498
September	43,207	40,088	36,813	35,497	32,642
October	43,041	39,472	37,138	35,023	32,186
November	42,915	36,984	39,628	34,522	32,293
December	44,883	40,149	42,643	34,919	32,293
Total	520,362	485,236	461,171	444,532	390,848

Base Metal Outputs.

		Nov.	Dec.
Broken Hill British	Tons lead carb. ore	—	365
	Tons lead conc.	—	1,140
	Tons zinc conc.	—	1,040
Broken Hill Prop.	Tons lead conc.	1,117	1,188
	Tons zinc conc.	4,322	4,863
Broken Hill South	Tons lead conc.	3,588	3,471
Burma Corporation	Tons refined lead	2,922	3,055
	Oz. refined silver	354,850	318,800
Mount Lyell	Tons copper	534	782*
	Oz. silver	15,345	18,168*
	Oz. gold	386	540*
North Broken Hill	Tons lead conc.	1,240	885
	Tons zinc conc.	1,340	960
Pilbara	Tons copper ore	100	60
Rhodesia Broken Hill	Tons lead	1,169	1,169
Sulphide Corporation	Tons lead conc.	1,828	2,394
	Tons zinc conc	3,281	4,282
Tanganyika	Tons copper	2,714	2,980
Zinc Corporation	Tons zinc conc.	9,735	8,915
	Tons lead conc.	842	795

* Eight weeks to January 11.

Imports of Ores, Metals, etc., into United Kingdom.

		December	Year 1921
Iron Ore	Tons	[illegible]	1,887,574
Manganese Ore	Tons	6,921	172,856
Iron and Steel	Tons	116,528	1,645,531
Copper and Iron Pyrites	Tons	29,596	[illegible]
Copper Ore, Matte, and Prec.	Tons	1,191	30,833
Copper Metal	Tons	4,075	86,810
Tin Concentrate	Tons	2,019	21,588
Tin Metal	Tons	1,866	20,967
Lead, Pig and Sheet	Tons	10,888	132,602
Zinc (Spelter)	Tons	8,355	72,486
Zinc Sheets, etc.	Tons	732	11,031
Quicksilver	Lb.	76,577	1,640,585
Zinc Oxide	Tons	390	[illegible]
White Lead	Cwt.	9,201	72,298
Barytes, ground	Cwt.	35,21	294,467
Phosphate of Lime	Tons	34,027	369,896
Mica	Tons	93	1,481
Sulphur	Tons	2,695	9,637
Nitrate of Soda	Cwt.	163,061	1,116,612
Petroleum: Crude	Gallons	20,186,481	99,592,619
Lamp Oil	Gallons	14,295,631	149,348,313
Motor Spirit	Gallons	17,984,184	251,098,155
Lubricating Oil	Gallons	5,354,109	50,966,045
Gas Oil	Gallons	9,613,690	76,826,082
Fuel Oil	Gallons	29,104,510	533,131,807
Paraffin Wax	Cwt.	81,811	784,686
Turpentine	Cwt.	39,182	[illegible]

Outputs of Tin Mining Companies.

In Tons of Concentrate.

	Oct.	Nov.	Dec.
Nigeria:	Tons	Tons	Tons
Associated Nigerian	—	—	—
Bisichi	45	45	50
Bongwelli	—	—	—
Champion (Nigeria)	—	—	—
Dua	—	—	—
Ex-Lands	30	30	—
Filani	6½	3	3
Gold Coast Consolidated	2	2	2½
Gurum River	11	12	10
Jantar	—	—	—
Jos	8	8	9
Kaduna	19	21½	17½
Kaduna Prospectors	13¼	16¼	16
Kefti Consolidated	20	25	25
Lower Bisichi	3½	4½	4¼
Mongu	66	59	52
Naraguta	50	55	70
Naraguta Extended	25	20	22
Nigerian Consolidated	6¾	9	13¼
N.N. Bauchi	55	60	52
Offin River	—	—	—
Rayfield	20	50	63
Ropp	133	135	125
Rukuba	4	3	4
South Bukeru	11	11	—
Sybu	—	—	—
Tin Fields	15	—	—
Yarde Kerri	7	7	6
Federated Malay States:			
Chenderiang	—	—	74*
Gopeng	92	89	71½
Idris Hydraulic	19½	21½	22
Ipoh	23¼	15½	20¼
Kamunting	—	—	71*
Kinta	41¼	39	41¾
Lahat	53½	48¼	53½
Malayan Tin	77½	89	76
Pahang	211	214	251
Rambutan	18	19½	20
Sungei Besi	48	54	54
Tekka	39	38	36
Tekka Taiping	23	24	21
Tronoh	15	30	28½
Other Countries:			
Aramayo Mines (Bolivia)	220	264	308
Berenguela (Bolivia)	29	41	42
Briseis (Tasmania)	20	20	—
Deebook Ronpibon (Siam)	30	21	16½
Leeuwpoort (Transvaal)	—	—	—
Macreedy (Swaziland)	—	—	—
Renong (Siam)	84¼	115	100½
Rooiberg Minerals (Transvaal)	—	—	—
Siamese Tin (Siam)	119	166	142
Tongkah Harbour (Siam)	60	60	87
Zaaiplaats (Transvaal)	—	—	—

* Three months.

Nigerian Tin Production.

In long tons of concentrate of unspecified content.

Note.—These figures are taken from the monthly returns made by individual companies reporting in London, and probably represent 85% of the actual outputs.

	1916	1917	1918	1919	1920	1921
	Tons	Tons	Tons	Tons	Tons	Tons
January	531	667	678	613	547	438
February	528	646	668	623	477	370
March	547	655	707	606	505	445
April	486	555	584	546	467	394
May	536	509	525	483	383	337
June	510	473	492	484	435	423
July	506	479	545	481	484	494
August	498	551	571	616	447	477
September	535	538	520	561	528	595
October	584	578	491	625	626	546
November	679	621	472	536	544	564
December	654	655	518	511	577	555
Total	6,594	6,927	6,771	6,685	6,022	5,618

Production of Tin in Federated Malay States.

Estimated at 70% of Concentrate shipped to Smelters
Long Tons.

	1917	1918	1919	1920	1921
	Tons	Tons	Tons	Tons	Tons
January	3,558	3,030	3,765	4,265	3,298
February	2,755	3,197	2,734	3,014	3,111
March	3,286	2,609	2,819	2,770	2,190
April	3,251	3,308	2,858	2,606	2,692
May	3,413	3,332	3,407	2,741	2,884
June	3,489	3,070	2,877	2,940	2,752
July	3,253	3,373	3,756	2,824	2,734
August	3,413	3,259	2,956	2,786	3,051
September	3,154	3,157	3,161	2,734	2,338
October	3,436	2,870	3,221	2,837	3,161
November	3,300	3,132	2,972	2,573	2,800
December	3,525	3,022	2,409	2,838	3,435
	39,833	37,370	36,935	34,928	34,446

Stocks of Tin.

Reported by A. Strauss & Co. Long Tons.

	Nov. 30	Dec. 31	Jan. 31
Straits and Australian Spot	2,112	2,019	1,823
Ditto, Landing and in Transit	483	635	745
Other Standard, Spot and Landing	5,948	5,196	5,518
Straits, Afloat	1,969	1,575	1,175
Australian, Afloat	70	70	75
Banca, in Holland	4,369	5,143	5,241
Ditto, Afloat	266	560	737
Billiton, Spot	121	121	166
Billiton, Afloat	31		—
Straits, Spot in Holland and Hamburg	—	—	—
Ditto, Afloat to Continent	900	425	350
Total Afloat for United States	4,671	6,833	8,235
Stock in America	1,316	1,696	1,321
Total	22,247	24,273	25,346

Shipments, Imports, Supply, and Consumption of Tin.

Reported by A. Strauss & Co. Long tons.

	Nov.	Dec.	Jan.
Shipments from:			
Straits to U.K.	1,395	1,825	1,125
Straits to America	1,985	3,700	4,020
Straits to Continent	685	395	370
Straits to other places	250	50	50
Australia to U.K.	150	220	210
U.K. to America	800	2,150	1,639
Imports of Bolivian Tin into Europe	977	1,032	811
Supply:			
Straits	4,065	5,920	5,515
Australian	150	250	210
Billiton	31	—	5
Banca	1,233	1,605	1,910
Standard	559	1,086	316
Total	6,038	8,861	7,956
Consumption:			
U.K. Deliveries	2,330	1,766	1,897
Dutch ,,	427	241	144
American ,,	3,250	3,710	4,275
Straits, Banca & Billiton, Continental Ports, etc.	675	1,170	567
Total	6,682	6,887	6,883

Imports and Exports of Gold and Silver

During year 1921.

		Imports.	Exports.
Gold:	Unrefined Bullion.... £	38,021,165	—
	Refined Bars........ ,,	6,154,084	56,270,494
	Coin .... ,,	5,501,076	3,077,664
Silver:	Unrefined Bullion ... oz.	5,787,244	—
	Refined Bars........ ,,	40,245,164	62,562,944
	Coin .... £	11,808,213	1,570,985

Outputs Reported by Oil-producing Companies.

		Oct.	Nov.	Dec.
Anglo-Egyptian	Tons	12,865	13,959	14,039
Anglo-United	Barrels	10,590	9,500	8,302
Apex Trinidad	Barrels	9,100	—	17,233
British Burmah	Barrels	76,412	71,050	73,300
Caltex	Tons	13,032	12,761	17,660
Dacia Romana	Tons	250	245	201
Kern River	Barrels	106,790	117,125	119,796
Lobitos	Tons	8,911	8,716	8,821
Roumanian Consol	Tons	2,222	1,800	1,633
Santa Maria	Tons	1,357	1,571	1,671
Steaua Romana	Tons	19,331	17,600	19,399
Trinidad Leaseholds	Tons	11,900	18,000	13,250
United of Trinidad	Tons	6,215	4,889	3,471

Quotations of Oil Companies' Shares.

Denomination of Shares £1 unless otherwise noted.

	Jan. 5, 1922 £	s.	d.	Feb. 6, 1922 £	s.	d.
Anglo-American	4	2	6	4	2	6
Anglo-Egyptian B	1	8	9	1	6	3
Anglo-Persian 1st Pref.	1	3	0	1	3	6
Apex Trinidad	1	17	6	1	11	3
British Borneo (10s.)		8	9		10	0
British Burmah (8s.)		16	3		13	9
Burmah Oil	5	17	6	5	12	6
Caltex ($1)		3	0		3	0
Dacia Romano		13	9		13	9
Kern River, Cal. (10s.)		18	6		18	6
Lobitos, Peru	4	5	0	4	6	3
Mexican Eagle, Ord. ($5)	3	11	3	3	16	3
,, ,, Pref. ($5)	3	8	9	3	13	9
North Caucasian (10s.)		15	0		13	9
Phœnix, Roumania		11	0		9	3
Roumanian Consolidated		9	6		7	9
Royal Dutch (100 gulden)	36	0	0	34	10	0
Scottish American		2	6		2	0
Shell Transport, Ord.	4	12	6	4	6	3
,, ,, Pref. (£10)	8	7	6	8	10	0
Trinidad Central	3	8	9	3	10	0
Trinidad Leaseholds	1	10	0	1	5	0
United British of Trinidad		13	9		12	6
Ural Caspian		15	0		13	9
Uroz Oilfields (10s.)		6	6		5	3

Petroleum Products Prices. February 9.

Refined Petroleum: Water white, 1s. 2d. per gallon; standard white, 1s. 1d. per gallon; in barrels 3d. per gallon extra.

Motor Spirit: In bulk: Aviation spirit, 2s. 6d. per gallon; No. 1, 2s. 2d. per gallon; No. 2, 2s. per gallon.

Fuel Oil: Furnace fuel oil, £4 per ton; Diesel oil, £5 10s. per ton.

American Oils: Best Pennsylvania crude at wells, $3·25 per barrel. Refined standard white for export in bulk, 7 cents per U.S. gallon; in barrels 13 cents. Refined water white for export in bulk, 8 cents per U.S. gallon; in barrels 14 cents.

Dividends Declared by Mining Companies

During month ended February 10.

Company	Par Value of Shares	Amount of Dividend
Sungei Besi	£1	1s. less tax.
Rambutan	£1	8d. less tax.
Deebook Dredging	£1	6d.*
Mond Nickel	Ord. £1	6d.
	Pref. £1	3½%
Aramayo Mines en Bolivie	25 fr.	5%
Great Boulder Proprietary	2s.	6d. tax paid.
Jupiter	£1	1s. 9d.*

* Refund of capital.

PRICES OF CHEMICALS. February 7.

These quotations are not absolute; they vary according to quantities required and contracts running.

		£	s.	d.
Acetic Acid, 40%	per cwt.	1	1	0
,, 80%	,,	2	2	0
,, Glacial	per ton	55	0	0
Alum	,,	16	0	0
Alumina, Sulphate	,,	14	10	0
Ammonia, Anhydrous	per lb.		2	2
,, 0·880 solution	per ton	28	0	0
,, Carbonate	per lb.			4
,, Chloride, grey	per ton	37	0	0
,, ,, pure	per cwt.	3	5	0
,, Nitrate	per ton	40	0	0
,, Phosphate	,,	80	0	0
,, Sulphate	,,	15	0	0
Antimony, Tartar Emetic	per lb.		1	6
,, Sulphide, Golden	,,		1	3
Arsenic, White	per ton	38	0	0
Barium Carbonate	,,	6	0	0
,, Chlorate	per lb.			7
,, Chloride	per ton	15	0	0
,, Sulphate	,,	8	0	0
Benzol, 90%	per gal.		3	0
Bisulphide of Carbon	per ton	56	0	0
Bleaching Powder, 35% Cl.	,,	14	0	0
,, Liquor, 7%	,,	5	0	0
Borax	,,	31	0	0
Boric Acid Crystals	,,	65	0	0
Calcium Chloride	,,	8	0	0
Carbolic Acid, crude 60%	per gal.		1	7
,, ,, crystallized, 40°	per lb.			5
China Clay (at Runcorn)	per ton	4	10	0
Citric Acid	per lb.		2	0
Copper, Sulphate	per ton	28	0	0
Cyanide of Sodium, 100%	per lb.			11
Hydrofluoric Acid	,,			7½
Iodine	per oz.		1	0
Iron, Nitrate	per ton	8	0	0
,, Sulphate	,,	3	0	0
Lead, Acetate, white	,,	41	0	0
,, Nitrate	,,	46	0	0
,, Oxide, Litharge	,,	37	0	0
,, White	,,	44	0	0
Lime, Acetate, brown	,,	7	0	0
,, ,, grey 80%	,,	10	10	0
Magnesite, Calcined	,,	21	0	0
Magnesium, Chloride	,,	11	0	0
,, Sulphate	,,	8	0	0
Methylated Spirit 64° Industrial	per gal.		4	0
Nitric Acid, 80° Tw.	per ton	27	0	0
Oxalic Acid	per lb.			8
Phosphoric Acid	per ton	36	0	0
Potassium Bichromate	per lb.			8
,, Carbonate	per ton	23	0	0
,, Chlorate	per lb.			6
,, Chloride 80%	per ton	12	0	0
,, Hydrate (Caustic) 90%	,,	33	0	0
,, Nitrate	,,	43	0	0
,, Permanganate	per lb.			9
,, Prussiate, Yellow	,,		1	3
,, ,, Red	,,		2	3
,, Sulphate, 90%	per ton	15	0	0
Sodium Metal	per lb.		1	4
,, Acetate	per ton	25	0	0
,, Arsenate 45%	,,	44	0	0
,, Bicarbonate	,,	12	0	0
,, Bichromate	per lb.			6
,, Carbonate (Soda Ash)	per ton	15	0	0
,, ,, (Crystals)	,,	7	0	0
,, Chlorate	per lb.			4
,, Hydrate, 76%	per ton	26	10	0
,, Hyposulphite	,,	12	0	0
,, Nitrate, 96%	,,	14	0	0
,, Phosphate	,,	19	0	0
,, Prussiate	per lb.			10
,, Silicate	per ton	11	15	0
,, Sulphate (Salt-cake)	,,	4	0	0
,, ,, (Glauber's Salts)	,,	4	10	0
,, Sulphide	,,	22	0	0
,, Sulphite	,,	12	10	0
Sulphur, Roll	,,	11	0	0
,, Flowers	,,	11	0	0
Sulphuric Acid, Fuming, 65%	,,	24	0	0
,, ,, free from Arsenic, 144°	,,	6	5	0
Superphosphate of Lime, 35%	,,	4	10	0
Tartaric Acid	per lb.		1	5
Turpentine	per cwt.	3	9	6
Tin Crystals	per lb.		1	5
Titanous Chloride	,,		1	0
Zinc Chloride	per ton	22	10	0
Zinc Oxide	,,	41	0	0
Zinc Sulphate	,,	16	0	0

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD, SILVER, DIAMONDS:

	Feb. 7, 1921 £	s.	d.	Feb. 6, 1922 £	s.	d.
RAND:						
Brakpan	2	17	6	2	6	3
Central Mining (£8)	6	10	0	5	15	0
City & Suburban (£4)		6	9		2	6
City Deep	2	3	9	2	2	6
Consolidated Gold Fields		17	6		15	0
Consolidated Langlaagte		15	9		12	6
Consolidated Main Reef		12	3		8	6
Consolidated Mines Selection (10s.)		15	0		12	3
Crown Mines (10s.)	2	5	0	1	15	0
Daggafontein		7	6		2	3
Durban Roodepoort Deep		2	6		4	0
East Rand Proprietary		5	6		4	3
Ferreira Deep		8	3		7	6
Geduld	2	5	0	2	10	9
Geldenhuis Deep		8	0		5	0
Government Gold Mining Areas	3	15	0	4	1	3
Johannesburg Consolidated	1	2	6	1	1	3
Kleinfontein		7	9		4	9
Knight Central		4	6		4	6
Langlaagte Estate		11	6		11	3
Luipaards Vlei		2	0		3	0
Meyer & Charlton	4	10	0	3	15	0
Modderfontein, New (10s.)	3	5	0	3	12	6
Modderfontein B (5s.)	1	10	0	1	8	9
Modderfontein Deep (5s.)	2	1	3	2	2	6
Modderfontein East		17	6		5	9
New State Areas	1	2	6	1	2	6
Nourse		7	9		8	9
Rand Mines (5s.)	2	5	0	2	0	0
Rand Selection Corporation	2	12	6	2	7	6
Randfontein Central		9	3		9	9
Robinson (£5)		8	9		9	0
Robinson Deep A (1s.)		10	0		7	6
Rose Deep		16	0		12	0
Simmer & Jack		3	0		2	6
Springs	1	12	6	1	16	3
Sub-Nigel		11	3		10	0
Union Corporation (12s. 6d.)		16	0		15	3
Van Ryn		11	3		10	0
Van Ryn Deep	3	10	0	3	6	3
Village Deep		8	3		6	9
West Springs		15	9		7	6
Witwatersrand (Knight's)		13	9		15	0
Witwatersrand Deep		7	6		7	3
Wolhuter		4	0		3	0
OTHER TRANSVAAL GOLD MINES:						
Glynn's Lydenburg		8	9		6	3
Transvaal Gold Mining Estates		8	9		6	6
DIAMONDS IN SOUTH AFRICA:						
De Beers Deferred (£2 10s.)	11	5	0	10	0	0
Jagersfontein	2	8	9	2	5	0
Premier Deferred (2s. 6d.)	5	0	0	4	10	0
RHODESIA:						
Cam & Motor		8	6		8	3
Chartered British South Africa		12	3		10	9
Falcon		9	6		4	0
Gaika		9	6		8	3
Globe & Phœnix (5s.)		17	6		11	9
Lonely Reef	2	7	6	1	17	6
Rezende	2	15	0	2	15	0
Shamva	1	7	6	1	8	9
WEST AFRICA:						
Abbontiakoon (10s.)		2	6		2	6
Abosso		8	6		6	6
Ashanti (4s.)		13	0		13	0
Prestea Block A		1	6		1	3
Taquah		8	0		7	9
WEST AUSTRALIA:						
Associated Gold Mines		2	6		5	6
Associated Northern Blocks		2	0		2	3
Bullfinch (5s.)		1	6		1	0
Golden Horse-Shoe (£5)		12	6		11	3
Great Boulder Proprietary (2s.)		6	0		5	0
Great Fingall (10s.)		1	6		1	0
Hampton Celebration		5	0		4	0
Hampton Properties		8	9		4	6
Ivanhoe (£5)	1	0	0		18	9
Kalgurli		8	9		3	6
Lake View Investment (10s.)		10	0		7	6
Lake View and Star (4s.)		2	6		1	9
Oroya Links (5s.)		1	3		1	3
Sons of Gwalia		3	9		3	0
South Kalgurli (10s.)		5	6		6	3

GOLD, SILVER, *cont.*	Feb. 7, 1921 £	s.	d.	Feb. 6, 1922 £	s.	d.
NEW ZEALAND:						
Blackwater		8	9		2	6
Waihi	1	5	0		17	6
Waihi Grand Junction		8	9		6	3
AMERICA:						
Buena Tierra, Mexico		5	0		1	9
Camp Bird, Colorado		5	6		3	3
El Oro, Mexico		10	6		8	0
Esperanza, Mexico	1	2	6		13	6
Frontino & Bolivia, Colombia		8	9		5	0
Kirkland Lake, Ontario		5	0		9	6
Le Roi No. 2 (£5), British Columbia		5	0		2	6
Mexico Mines of El Oro, Mexico	4	15	0	3	7	6
Nechi (Pref. 10s.), Colombia		7	6		5	0
Oroville Dredging, Colombia	1	3	9	1	3	9
Plymouth Consolidated, California		17	6		5	0
St. John del Rey, Brazil		15	0		16	6
Santa Gertrudis, Mexico		7	0		4	9
Tomboy, Colorado		6	3		6	3
RUSSIA:						
Lena Goldfields		12	6		8	9
Orsk Priority		5	0		5	0
INDIA:						
Balaghat (10s.)		7	0		6	6
Champion Reef (2s. 6d.)		2	3		1	9
Mysore (10s.)		11	9		11	0
North Anantapur		3	0		2	6
Nundydroog (10s.)		6	0		7	6
Ooregum (10s.)		11	3		11	9
COPPER:						
Arizona Copper (5s.), Arizona	1	10	0		15	0
Cape Copper (£2), Cape and India		15	0		8	9
Esperanza, Spain		5	0		4	6
Hampden Cloncurry, Queensland		6	3		5	0
Mason & Barry, Portugal	1	10	0	1	18	9
Messina (5s.), Transvaal		4	0		3	0
Mount Elliott (£5), Queensland		12	6	1	0	0
Mount Lyell, Tasmania		13	9		13	9
Mount Morgan, Queensland		12	6		12	0
Namaqua (£2), Cape Province	1	2	6	1	0	0
Rio Tinto (£5), Spain	26	0	0	26	10	0
Russo-Asiatic Consd., Russia		7	6		10	0
Sissert, Russia		10	0		5	0
Spassky, Russia		10	0		12	6
Tanganyika, Congo and Rhodesia	1	5	0		18	9
LEAD-ZINC:						
BROKEN HILL:						
Amalgamated Zinc		18	9		11	3
British Broken Hill		17	6	1	0	0
Broken Hill Proprietary	2	0	0	1	2	6
Broken Hill Block 10 (£10)		12	6		7	6
Broken Hill North	1	7	6	1	5	0
Broken Hill South	1	6	3	1	3	9
Sulphide Corporation (15s.)		12	6		7	6
Zinc Corporation (10s.)		10	0		7	6
ASIA:						
Burma Corporation (10 rupees)		8	0		5	3
Russian Mining		6	3		4	6
RHODESIA:						
Rhodesia Broken Hill (5s.)		8	3		5	0
TIN:						
Aramayo Mines, Bolivia	2	10	0	2	0	0
Bisichi (10s.), Nigeria		6	3		6	0
Briseis, Tasmania		4	6		3	3
Chenderiang, Malay		15	0		11	3
Dolcoath, Cornwall			3			9
East Pool (5s.), Cornwall		4	0		3	0
Ex-Lands Nigeria (2s.), Nigeria		2	0		1	6
Geevor (10s.), Cornwall		3	9		3	0
Gopeng, Malay	1	10	0	1	16	3
Ipoh Dredging, Malay		12	6		8	9
Kamunting, Malay	2	10	0	1	1	3
Kinta, Malay	1	12	6	1	18	9
Lahat, Malay		12	6		10	0
Malayan Tin Dredging, Malay	1	7	6	1	2	6
Mongu (10s.), Nigeria		12	6		10	0
Naraguta, Nigeria		11	3		13	9
N. N. Bauchi, Nigeria(10s.)		1	6		2	0
Pahang Consolidated (5s.), Malay		6	6		5	3
Rayfield, Nigeria		3	6		2	0
Renong Dredging, Siam	1	10	0	1	2	6
Ropp (4s.), Nigeria		6	6		6	0
Siamese Tin, Siam	2	10	0	1	17	6
South Crofty (5s.), Cornwall		5	6		4	0
Tehidy Minerals, Cornwall		10	0		5	0
Tekka, Malay	1	0	0		18	9
Tekka-Taiping, Malay	1	3	9	1	0	0
Tronoh, Malay	1	5	0	1	6	3

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

In this section we give abstracts of important articles and papers appearing in technical journals and proceedings of societies, together with brief records of other articles and papers; also notices of new books and pamphlets, lists of patents on mining and metallurgical subjects, and abstracts of the yearly reports of mining companies.

ROMAN MINING LAWS.

In our issue of August, 1921, we quoted a paper by Professor Henry Louis, read before the Royal Cornwall Polytechnic Society, giving some particulars of three Roman tablets recently discovered in Portugal, dealing with various mining regulations. This paper referred chiefly to those portions of the tablets which showed the method of keeping accounts and raising of working capital, the tendency of which indicated a probable origin of the Cornish cost-book system. Professor Louis has since read a paper before the University of Durham Philosophical Society, giving further details of these tablets. We quote herewith the sections of his paper dealing with the mining regulations.

The first of these tablets, found in 1876, is numbered III, and is evidently the third of a series, though unfortunately it is the only one that has been discovered. It is divided into nine clauses (the last of which is incomplete), and refers to the financial administration of the mining camp. The first clause shows that there was an auctioneer appointed for the mining camp, who had to conduct all sales by auction, and it fixes the auctioneer's commission at 1%, which is to be doubled if not paid within three days; any sales by auction ordered by the warden must be conducted by the auctioneer gratuitously. The next clause fixes in the same way the payments to be made to the public crier; one of the interesting details is that when a mine shaft is sold by order of the warden the purchaser must pay the crier's commission of 1%. The third clause sets out the obligations incumbent upon the farmer of the baths, of keeping them in good order, with a proper supply of hot water, specifies the bathing hours for men and women, and the payments to be made for the use of the baths, which are, however, to be free for public servants, soldiers, and youths under age. The next three clauses regulate the conditions under which cobblers, barbers, and fullers may exercise their respective trades.

The next clause is decidedly difficult to interpret; it states that anyone engaged in cleaning, dressing, or reducing copper or silver slags in the district shall declare how many men he has engaged in this work, and shall make a monthly payment for each man to the farmer (apparently the farmer of the smelting rights) and that payments shall also be made to him by anyone importing copper or silver slags into this mining camp. The clause is headed "*Scripturæ scaurariorum et testariorum*," and the latter word appears to offer some difficulty. Professor Louis considers that it is quite probable that the Romans refined silver here, and that the word applied to the men working at the "test" or cupel upon which such refining would be carried out. The Latin "testa" appears to have originally meant a flat shell, a potsherd, or a shallow earthenware vessel, and such a vessel containing a layer of ashes would probably be used for silver refining; in the earliest descriptions of silver cupellation a vessel of this description was so used; Agricola, writing in the seventeenth century, calls it *testa*, and the word "test" is still applied to-day to the similar vessel used in the English cupellation hearth. There is, of course, ample evidence that the Romans were familiar with the method of cupellation.

The eighth clause enacts that within the mining district teachers shall be exempt from taxation.

The last clause, unfortunately unfinished, refers to the penalties to be paid by anyone who jumps another man's shaft or shaft-site, contrary to the mining law "*e lege metallis dicta*."

It will be seen that there is an immense amount of interesting matter in this tablet. It is, however, far inferior in importance from the mining point of view to the second tablet, found thirty years later under similar conditions. This is evidently not a portion of the series to which the first belongs, as it differs widely from it both in matter and in style. In all probability it is a portion of the laws applied to mines throughout the colonies of the Roman Empire, possibly with minor qualifications to suit local conditions, but it may be supposed that its general lines were the same for all, and that it was drawn up in Rome itself and was distributed to the various colonies affected by it. If this view is correct, there is here an example of the legislation that governed mining in Great Britain 1,800 years ago.

The first line of this tablet begins in the middle of a sentence, and deals with the penalties to be imposed upon anyone who smelts any ore before he has paid the price thereof as previously stated (this is not known, as the conditions were evidently contained in the tablet preceding). The penalty is that the owner of the shaft who commits this breach of the law shall have his share of the shaft confiscated, and that the warden shall put the whole shaft up for sale. Furthermore, the informer who proves that ore has been smelted before the owner has paid the price of the half share belonging to the State shall receive a fourth part as a reward. It is important to note that two different words, namely "*occupator*" and "*colonus*" are used in this paragraph indifferently as meaning the person in possession of the shaft; these words are used repeatedly throughout this inscription and apparently without any difference of meaning. Professor Louis translates them both by the term "mine-owner," although, as he says, it is obvious that there is no ownership in the sense in which that term is now used.

The rest of the inscription is sufficiently important to deserve translation in full, as follows: (2) Silver-bearing shafts shall be worked in the manner contained in this law; the prices thereof according to the generosity of the Most Sacred Emperor

Hadrian Augustus shall be determined in such a manner that the ownership of that share that shall belong to the Treasury may belong to him who first offers the price for the shaft and pays into the Treasury the sum of 4,000 Sesterces.

(3) Whosoever out of the number of five shafts shall have sunk one down to the ore shall work without intermission in the others as is written above ; unless he shall do so others shall have the power of occupying the same.

(4) If anyone after 25 days given to preparation for the expenses shall have forthwith commenced to carry out some work but shall afterwards have ceased from working for ten consecutive days, others shall have the right of occupation.

(5) A shaft having been sold by the Treasury and having lain idle for six consecutive months, others shall have the right of occupation provided that when ores are drawn from the same, one-half share shall according to custom be reserved to the Treasury.

(6) The owner of the shafts shall be allowed to have such partners as he may desire, provided that the latter shall contribute to the expenses for that share by which each is a partner. Should he not do so, he who has made the disbursements shall for three successive days in the Forum, and in the most frequented parts, cause the amount of the disbursements made by him to be published, and he shall intimate by crier to his partners that each shall contribute to the expenses according to his share. Whosoever shall not contribute, or with evil intent shall have done something so that he may not contribute, or whereby he may deceive one or more of his partners, shall be deprived of his share in the shaft, and that share of the partner shall belong to those partners in proportion as they shall have paid the disbursements.

(7) And those mine-owners who shall have made disbursements in that shaft in which there shall have been several partners shall be entitled to recover from their partners what shall be shown to have been expended in good faith.

(8) The mine-owners shall be allowed to sell among each other also the shares of the shaft, which they may have bought from the Treasury and paid the price thereof, for as much as they can obtain ; whosoever wishes to sell his share or to buy must make a declaration before the warden in charge of the mines ; it shall not be lawful to sell or buy in any other wise. Whosoever is in debt to the Treasury shall not be allowed to give away his share.

(9) The ores lying close to the shaft-mouth shall be transported to the smelting works between sunrise and sunset. Whosoever is convicted of having transported ore from the shafts after sunset shall pay a fine of 100 Sesterces to the Treasury.

(Professor Louis translates the word *officina* as " smelting works " ; it is the origin of the French " usine," and appears to mean a works as distinct from a mine, and may here have included a refinery as well as a smelting works properly speaking.)

(10) Anyone who steals ore, if a slave, shall be flogged by the warden and sold by him under the condition that he shall remain in fetters for all time, and shall not be allowed to dwell in any mines or mining district ; the price of the slave shall belong to his master ; if he is a freeman the warden shall confiscate his goods, and he shall be forbidden all mining districts for ever.

(11) All shafts must be carefully stayed and supported, and the owner of each shaft must replace any decayed material by such as is new and suitable.

(12) It is forbidden to touch or injure the pillars or supports left for the sake of strength or to do anything with evil intent whereby these pillars or supports may be weakened and less easy to traverse.

(13) Whosoever shall be convicted of damaging a shaft, causing it to cave, or destroying the upper part, or doing anything with evil intent whereby the shaft may be rendered less firm shall, if a slave be flogged as the warden may determine, and be sold by his master subject to the condition that he shall not be allowed to dwell in any mines ; if a freeman the warden shall confiscate his goods to the Treasury, and he shall be forbidden mining districts for ever.

(14) Whosoever works copper shafts shall keep away from the drift that carries the water away from the mine and shall leave not less than 15 ft. on either side thereof.

(15) It is forbidden to damage the drift. The warden may give permission to work a trial hole from this drift for the sake of seeking for a new mine so that such trial shall not be more than 4 ft. high and wide. (In this clause there is a word " *ternagus* " which appears to be new, and is not found in the dictionaries ; Professor Louis translates it as a " trial working," which is evidently from the context what it is intended for, but there is no clue to the way in which this meaning is derived.)

(16) It is forbidden to seek for or to cut ore within 15 ft. of either side of the drift. Whosoever is convicted of doing otherwise in the trial holes shall, if a slave, be flogged as the warden may determine, and be sold by his master under the condition that he shall not be allowed to dwell in any mines ; if a freeman his goods shall be taken by the Treasury, and he shall be forbidden mining districts for ever.

(17) Whosoever works silver shafts shall keep away from the drift that carries the water away from the mine, and shall leave not less than 60 ft. on either side thereof, and he shall keep in work those shafts which he possesses or which have been assigned to him as their boundaries shall have been set, nor shall he go beyond those, nor shall he collect waste nor make trial holes beyond the limits of the shaft assigned to him in such a way as to . . .

It is evident that this fragment contains a summary of a number of general laws governing the ownership of mines and the conditions under which they might be worked. It is clear in the first place that the ownership of the minerals was vested in the State ; apparently the State allowed any would-be miner to sink shafts for the sake of extracting the ore, at his own expense, subject to the condition that, when he raised ore, one-half thereof was to belong to the Treasury. Probably the tribute of ore was taken in kind and smelted on account of the Treasury ; this provision would make it quite intelligible why it should be forbidden to remove any ore after dark when the representatives of the Treasury would be unable to see the quantity and quality of the ore thus removed. It would further seem that if any owner of a shaft abandoned it for a certain time or did not comply with all the conditions as to payment, etc., his ownership was forthwith determined, and the entire shaft fell into the hands of the Treasury ; it was then apparently put up to auction or otherwise sold, and the purchaser apparently purchased subject to the same condition, namely, that one-half of the ores extracted belonged to the Treasury. In other words the owner of the mine was the owner only as long as he complied with the conditions laid down and paid royalty to the State, the royalty in this case amounting to 50% of the produce. It would appear that the State claimed the absolute ownership of the mineral, but allowed it to be worked under certain conditions, most of which are unfortunately missing from the tablet that has come down to us. In the first place it may be conjectured that anyone, or possibly any settler in the mining district, wishing to mine, would be allowed to stake out a claim, probably of a certain defined area, and to mark upon it his proposed shaft sites. In most countries to-day, where the State owning the mineral allows claims to be pegged out in this way, the claim-holder is bound to execute a certain amount of work in order to make good his right; it would appear that under these laws the amount of such assessment work was fixed by the Romans at sinking five shafts down to the ore. After he had done this work, the claim-holder probably became the absolute owner of the claim. If he failed to do his assessment work his right lapsed and others could take it over, or in Australian phraseology, "jump his claim." Until he had completed his assessment work he must keep at it continuously, a stoppage of ten successive days rendering his claim liable to be jumped; it may be conjectured that under certain conditions that have not come down to us, the claim reverted to the State, and was then put up for sale by auction. If these views are correct, the ownership of a mining claim and of the shafts upon it could be secured either by staking out and doing the requisite amount of work, by jumping a derelict claim and completing the assessment work, or by purchase from the State. In all cases the owner held the mines subject to the condition of paying to the State one-half of the produce of the mine. The first clause, unfortunately imperfect, is by no means easy to understand; it may perhaps mean that the mine owner could purchase from the State the royalty rights by the payment down of certain sums, and in such case would be entitled to dispose of the whole of the proceeds of his mine, but this interpretation is by no means devoid of difficulties. It is possible that some such distinction may be implied in the use of the two words *occupator* and *colonus*, both of which appear to mean mine-owner, though probably implying some difference in the mode of ownership. On the other hand, *colonus* may mean a man who has been settled within the limits of the mining camp, and it is probable that these last alone had the right to peg out mining claims; if this is the correct interpretation, every *occupator* must be a *colonus*, though a *colonus* would not necessarily be an *occupator*. The meaning of the word *colonus* as applied to land is fairly well known; the *colonus* was a freeman, who enjoyed fixity of tenure in respect of the land he cultivated, but was bound to that land upon which he was settled; he had to pay a proportion of the produce of the land to the proprietor whoever he might be; if these conditions are transferred to a mining property, it might be deduced that the *colonus* of a mine enjoyed the absolute right of ownership of the mine, but he had to remain a miner and had to pay a proportion, here fixed at one-half, of the produce of the mine to the State as his over-lord.

It may be noted that there is no mention here of any compensation for the owner of the surface. It is, however, quite conceivable that in such a mining district the State may have reserved all surface rights to itself, and that the mineral royalty was deemed to include payments for surface rights. It was not until much later than the date of these tablets that we find in Roman law any recognition of the rights of the owner of the surface, although ultimately the miner had to pay to the owner of the surface one-tenth of the produce, the royalty to the State having by that time been reduced to that amount.

THE MINERAL RESOURCES OF UGANDA

We conclude herewith our extracts from the first annual report of the Geological Department, Uganda Protectorate, covering the year ended March 31, 1920, and written by E. J. Wayland and W. C. Simmons.

There is abundant evidence that the more enlightened natives wish to be instructed in industrial arts and crafts, and some blacksmiths, at any rate, are anxious to be taught how to improve their output and the quality of their productions. Native tools of British manufacture can, of course, be purchased in the markets, but it is significant that in Teso last year the Lukiko engaged a party on Banyoro smiths to teach the Bateso how to smelt iron and manufacture their own implements. Unfortunately the attempt failed, on account of the inability of the Banyoro to discover any iron deposits worth working. Similarly, smiths imported from Bunyoro have searched the Lango district in vain for workable ore elsewhere than at Kaganga Hill.

In his annual report for the year 1905-6 Assistant Collector Jervoise called attention to the importance of the native iron industry in the Masindi district. The export of native hoes was then, it seems, about 1,000 per month. These found their way more or less all over the Protectorate. Mr. Jervoise was of opinion that the attempt should be made to improve local methods of smelting and smithing, and thereby increase the output not only for the benefit of the Masindi smiths, but for the country in general. The importation of a small smelting furnace was suggested and local advice sought. Sir Henry Hesketh Bell, who was at that time Commissioner for Uganda, expressed himself strongly in favour of an attempt to instruct the iron workers in improved methods and suggested that it might prove profitable to work the ore on a considerable scale. On his recommendations a sample of the Masindi ore and a native hoe were sent to Professor Wyndham R. Dunstan at the Imperial Institute for analysis and report. Meanwhile, steps had been taken to ascertain what had been done by way of encouraging native smiths at Kisumu, British East Africa, but the result of the inquiry being unsatisfactory the already proffered services of Mr. D. Bennett, of Wadelai, engineer of the Marine Department, were secured. Mr. Bennett started work in November, 1906. Having instructed the natives in the Budongo forest in the art of making charcoal on the smothered principle, he built a temporary workshop, a smith's fire of bricks, two sets of bellows, and a bench and vice. The native smiths were instructed in brazing, punching, and splitting, the manner of welding collars on round iron, how to bore iron, how to work cast steel and temper it, and how to work the newly smelted iron until it gained the requisite tensile strength and quality. Mr. Bennett succeeded in getting the natives to use European tools, and the smiths working under his instruction turned out 2 lb. and 4 lb. hammers, smith's tongs, bolts, nuts, and hinges. The chief difficulty met with in the experiment was the want of a good blast, and in order to get over this Mr. Bennett suggested the importation of a Shields patent fan, with the necessary driving wheel, belting, cisterns, flue irons, piping, and couplings complete. The then price in London of this outfit together with two 3 cwt. anvils was £45 ; this, of course, was for hand power, but it was thought probable that the better method would be to transport the ironstone, or the smelted ore, to a site where power was available for actuating a water-wheel fitted to drive a blast-fan and drop-hammer. By this means Mr. Bennett stated that it would be possible to turn out bar iron of about 4 in. square in transverse section. The additional cost for this plant was, then, about £60 in London. Mr. Bennett was unable, owing, no doubt, to the lack of appliances, to improve upon the native methods of smelting, and it does not appear that, after his departure, early in December, 1906, the good work started by him was continued by others.

On June 4, 1907, the analysis of the ore-sample submitted was received from the Imperial Institute. It transpired that the ore was not of high quality and only suitable for local smelting, the iron content being rather low and the phosphorus high. The actual figures were: Fe 46·5%, Mn absent, SiO_2 8·51%, P 0·69%, S 0·05%. Moreover, hoes of similar quality to those of native manufacture of which the local price was about 8d. each could be made in England, packed and delivered f.o.b. English ports at 4s. 6d. per dozen, which, in view of the comparatively low freights at the time, suggested, on the face of it, the sale of English-made hoes with a fair margin of profit in Uganda. As it happened, there was not, at the time, a single English hoe of any kind offered for sale in Uganda, and it was arranged that a firm in the Protectorate should order 100 English hoes of native type, in order to see what they would cost at Masindi and whether the native would buy them in preference to those produced locally. It was discovered that the cost of transport killed all the expected profits and that the native hoes were cheaper than the English equivalent. Thus, in the circumstances the desirability of constructing an adequate smelting furnace was considered. Professor Dunstan suggested a Catalan, and provided all the necessary details.

Capt. J. Macqueen called attention to the enormous deposits of iron ore in the Masindi district and to the fact that the sample sent to the Imperial Institute for analysis was purely surface stuff. He suggested that the great power of Murchison Falls might be used in part for the purposes of electric smelting, and learnt that Professor Dunstan had already suggested it: "If at any time electricity is generated the establishment of electric furnaces should not be overlooked. The iron ore of Uganda is suitable for electric smelting. The extent of ore deposits are unknown and must be gone into before proposals for electric smelting could be made." But little information with regard to electric smelting was then available. Professor Dunstan suggested that J. S. Coates, Geologist to the Anglo-Congolese Boundary Commission, who was in the country at the time, should be asked to examine and report on the area and send to the Imperial Institute samples of the ore. There is no record here, however, to show whether this was done or not.

Unfortunately the iron industry at Masindi suffered considerably during 1907–8 owing to chiefs seizing on the smiths (who were quickly and easily obtainable) for transport work. "On this being brought to the notice of the Assistant Collector in charge," writes that official in November, 1908, "arrangements were made for the registration of the iron workers and instructions were issued to the chiefs forbidding the employment of these men on transport work. During the last few months a large trade has been developing in native tools, that is hoes and axes, with Bukedi ; the hoes having a trade value of one rupee each. About 2,000 hoes have been taken up to Bukedi during the last two months, and I hear that several Indian traders are holding large stocks in various parts of the district, one trader having 1,500 to 2,000 native hoes at Kisalizi."

An attempt was made in 1909 to erect a Catalan, and at the request of the Director of the Imperial Institute a sample of ore from below the surface was dispatched to England for analysis. The sample was taken from a depth of 5 ft., and showed a higher percentage of iron than did the ore previously analysed 54% metallic ores. The analyst pointed out that the ore "contains, however, too much phosphorus to be suitable for the production of steel by modern European methods, except the basic bessemer process, but is suitable for smelting by native methods." The then Acting Chief Secretary, reporting to the Imperial Institute in March, 1911, said: "A furnace was erected at considerable expense to the Administration, but the results have been unsuccessful. Officers who have been in charge of the Masindi district report that the natives much prefer their own methods to our suggested innovations. The labour of the transport of ore to a central furnace also makes the use of such a furnace impracticable for any natives save those in the near neighbourhood. I consulted Mr. McClure, the Acting Chief Engineer, and after careful consideration he informed me that in his opinion, in view of the limited amount of ore worked and the question of transport, the native method was probably the more satisfactory in the circumstances. He states that the native methods are sound in all essentials. So far as the natives are concerned, therefore, it appears to me that the transport of the ore is at present too costly and prevents this scheme from being brought to a successful conclusion commercially. It is not proposed to press this subject further as far as the natives are concerned."

It is difficult, and perhaps somewhat unfair, to judge by minute papers alone, but it is felt that however earnest the original desire to improve the native industry may have been, long delay and local difficulties damped the ardour of those who were finally responsible for the actual experiment; and one is constrained to wonder what a little more sticking power and a little more initiative might have achieved. At any rate, the last word on the possibility of the iron industry in the Protectorate has not yet been said; and, indeed, in view of the present high prices of steel and iron goods in England, and the costly freights that are now imposed, the problem of developing the iron resources of Uganda must again come up for consideration.

The iron industry at Masindi has declined very considerably of late years, partly no doubt from local causes, and partly on account of the introduction, before the war, of cheap hoes of German manufacture. These were sold at the rate of two or three for one rupee, the price varying with size and quality. According to the agents for these articles at Jinja, the demand between December and April was usually at least 100,000. This was for the Eastern Province alone. A similar hoe of English manufacture could be bought for 60 cents to 75 cents, according to locality. Masindi hoes, of which very few were made, and those chiefly for sale in West Lango, were priced at 75 cents each. Britain's too considerable dependence on German enterprise was brought home to Uganda as well as to most British Colonies and dependencies. Before 1915 the cessation of the hoe supplies from Germany was making itself felt, and during that year the position threatened to become very acute owing to native cotton-growers being unable to procure tools for their industry. In 1916 the cheapest hoe obtainable in Mbale was priced at 1·25 rupees, while at out-centres they cost 1·50 rupees; and in view of the high price of imported tools one trader, Mr. E. Bonini, of Jinja, applied in February, 1918, for a licence to prospect for iron deposits in the Hoima and Masindi districts, with a view to establishing a hoe-factory, which was to be placed under European supervision. It does not appear, however, that he ever took the licence up.

It was thought that cheap hoes might be obtained from South Africa, but on inquiry the prices were found to be 2, 2·19, 2·34, and 2·65 rupees each f.o.b. Durban, while local prices in Uganda for hoes already imported from elsewhere ran in some places from 1·50 to 3 rupees each. An attempt was made to revive the smithing industry at Masindi, but it does not seem to have been effectual.

Native smiths are slow workers and their methods are often wasteful; they have, too, a predilection, founded on experience, to the use of low-grade ores. Provided that the market is large enough to justify manufacture on at least a moderate scale, it should be possible with good conditions and proper organization to turn out a better and cheaper article than the smiths now produce.

Manufacture of Iron and Steel Goods.—His Excellency the Governor has raised the question of the local production of light rails, iron sleepers, and telegraph poles, etc. The main causes leading up to the inquiry are the present trade conditions of Europe and the consequent high prices. These, taken together with the isolated position of Uganda and the heavy transport charges, especially on the Uganda Railway, which, like the cost of commodities themselves, are not likely to decrease very sensibly for a considerable time, open up the way for inquiries which in normal pre-war times might have been uncalled for. It is doubtful whether an iron and steel industry designed to supply the wants of Uganda alone in the matter of constructional iron and steel goods would be financially sound. It would almost certainly not be if plant comparable to that made use of in great iron-producing centres had to be installed, but it is by no means certain that with simpler appliances and more modest aims a local industry for local needs would not be a business proposition. In either case other markets must be looked for, and there should not be much difficulty in discovering them. High-grade iron ores exist, and there are reasons for believing that in certain areas they exist in quantity. Flux, in the form of dolomite, is known to occur in enormous quantity in the Eastern Province, and fuel, in the form of charcoal, could be manufactured on a large scale. Given the necessary materials advantageously placed, the success of the enterprise depends, of course, very largely on costs, but these can only be estimated properly when all the conditions are known. Thus, the first point to be proved is the existence of a good supply of suitable ore well situated with regard to fuel, flux, water, and transport. This matter is receiving investigation at the present time, and five samples have been sent to England for commercial analysis and valuation.

It is a common opinion that no smelting other than that of a very primitive nature can be done in this country without the aid of coal, and it is further held that the discovery of coal would solve a great many difficulties in this direction. It is, however, far from certain that this is the case, for by no means are all coals suitable for use in blast-furnaces without previous coking; nor will all coals yield a coke sufficiently free from sulphur, phosphorus, and other impurities to allow of the production of good-quality steel and iron; and, again, if uncoked coal is used the necessary plant for the collection and preparation of useful by-products would have to be erected and markets found for the substances produced. Thus everything points to the use of charcoal. It has been objected that this is impracticable, since the calorific value of wood is so low, but it must be remembered that the function of the fuel in an iron-smelting furnace is not merely that of heat-generation, but that of reduction. Moreover, while the calorific value of wood is about 2,700, the calorific value of charcoal is 8,080. One of the chief objections to the use of charcoal is that it involves the destruction of large quantities of timber, which might be put to other and more permanent uses; thus, when coal or coke is available in quantity the use of charcoal is not to be considered. Now, in Uganda there are large areas from which timber not only could be removed, but in the interests of health should be removed, and that speedily.

The problem of the iron and steel industry in Uganda falls under three main heads; (*a*) the improvement of the present native industry; (*b*) the Europeanizing of the native industry; and (*c*) the introduction of essentially European methods and appliances for the manufacture of goods for local and adjoining European markets. In all these cases methods of smelting other than those now employed in Uganda must be introduced. For the purpose of improvement of the local industry natives must be taught not only how to make a greater variety and better quality of tools, but also the best ores for particular purposes; and the natives must be shown how, by the use of better furnaces and a much more effective blast, to turn out more material in less time. A Shields fan and a simple kind of furnace have already been suggested, but not tried; a Catalan has been suggested, tried, and in the circumstances found wanting. The writers have no doubt that the Catalan, which has been used with such good results in Europe, is, when adapted to local conditions, the type of furnace best suited to the native industry in Uganda. Owing to the mechanism by which the blast is produced, a Catalan cannot be erected wherever ore, fuel, and flux are easily available. It must, in fact, be placed conveniently near running water which can be trapped at a level somewhat above the cistern and not too far away from it. The necessary conditions are seldom met with except in the vicinity of mountain streams or waterfalls; and, unfortunately, the continuous supply of water necessary to the proper working of the blast, which would probably be in the neighbourhood of 2,000 gallons per hour, cannot be supplied from below through the medium of a ram or any practicable form of force or suction pump; but a small air-lift installation would solve the difficulty admirably, and thus serve greatly to minimize a factor which limits to so large an extent the use of this type of furnace.

Details of certain schemes over and above that of electric smelting, which will have to be seriously considered before long, are being worked out at the present time, but they are not yet sufficiently advanced to warrant publication now. It would seem probable, however, that in one district, at any rate, it may be possible to produce a good class of pig-iron at £6 per ton.

MANGANESE.—Manganese, in small quantities, is widely distributed in Uganda. It occurs in association with the ores of the lateritic ironstones, and in nodules in surface deposits; the ore generally takes the form of pyrolusite. A quartz-rock, associated with the argillites in the Botanical Gardens, Entebbe, carries thin plates and films of pyrolusite along its joint and fracture planes. Manganese is not likely to be of any commercial value in Uganda except in the event of the establishment of an iron and steel industry.

CHROMIUM.—Chromite occurs in connexion with mica-schists, and is found as the "iron ore" content of some basic intrusions. It has not yet been found in large quantities. Roccati records it from Ruwenzori. It is extremely doubtful whether it will ever pay to export chrome ore from Uganda.

ZINC.—The usual zinc ores have not been found in the Protectorate, but franklinite has been found in small quantities in some pegmatites. In America franklinite is used as a double ore, that is, of zinc and iron. It is of no value at present in Uganda.

COAL.—Coal has been reported from two places in the Protectorate, but both discoveries await confirmation. Coal is known in the Karroo (Permo-Carboniferous, or Permo-Triassic) beds of the Tanganyika Territory, near the mouth of the Ruhuhu River, and on the opposite side of Lake Nyasa in the Nyasaland Protectorate; while coal beds of a very promising nature are cut by the Songwe (Songue) and Kivira Rivers to the north-west of the lake. Coal is also known on the western shores of Lake Tanganyika, in the Congo, in beds of similar age. The age of the argillite series is not definitely known, but, in all probability, they are to be correlated with the Karagwe beds of the Tanganyika Territory, which themselves belong to the Karroo series. Thus it will be seen that the question of the occurrence of coal in Uganda is one deserving of investigation. Since the close of the financial year 1919-20 some preliminary investigations have been made and have resulted in an important discovery. Some unaltered beds of the argillite series have been found; these yield fossil-plant impressions. The remains as yet brought to light are very fragmentary and cannot be determined with absolute certainty, but the two genera *Gangamopteris* and *Psygmophyllum* appear to be represented. It would seem, then, that the argillites are wholly, or in part, of Permo-Carboniferous age (Lower Karroo), and may be correlated with the coal-bearing beds of the Tanganyika Territory. It is to be remarked, moreover, that the Ecca coal-measures of South Africa are of similar age and yield similar remains. Another possibility is the existence of lignite in Miocene beds, which may flank the great lakes.

PETROLEUM.—For some years past petroleum has been known to exist in the vicinity of Lake Albert. The oil seepage which is to be seen on the shore about 3 miles north of Kibero consists of a mixture of heavy bituminous oil and sand saturated with water. A report of an analysis of the material made at the Imperial Institute shows that, as far as the sample dealt with was concerned, 9% of water separated on standing and a further 19% was removable by distillation. The dry material thus obtained was a black, semi-fluid oil, having a specific gravity of 0·961 (at 15° C.). When subjected to fractional distillation it yielded 1·1% light petroleum, 12·4% kerosene, 55·6% of lubricating oils and solid hydrocarbons, and 30·9% residue consisting of coke and pitch. The characteristics of the light petroleum and the kerosene obtained by distillation, show that these products were not present originally in this sample of oil, but were produced by the "cracking" of the solid hydrocarbons, which took place during the distillation. The original oil is essentially of a highly bituminous character, and the proof of this is afforded by the behaviour of the sample when examined as a bitumen or natural pitch. Though the oil is too viscous for use as marine fuel, it might possibly be employed as a fuel for a Diesel type of engine consuming heavy oils, since it has a high calorific value, and contains very little sulphur. This bituminous material from Lake Albert is chiefly of interest as furnishing surface evidence of the probable existence of petroliferous strata in the region where it was found, and the occurrence should be fully investigated.

A preliminary geological survey of the area near Kibero has already been made but the results to date are not very encouraging. There can be little doubt that the oil is coming up the scarp fault. The rocks near Kibero are far from attractive from the oilman's point of view. A seepage appears not only at Kibero, but, so the native fishermen say, also on the Congo side. Moreover, the fishermen tell of "explosions" which sometimes occur well "out to sea" in the lake. They say a rumbling noise is accompanied by an uprush of water and oil. The presence of a seepage or two cannot be regarded as indicating the presence of commercial quantities of oil; nor must the existence of a hot spring and salt near Kibero be taken as corroborative evidence, although such things are commonly classed as hopeful indications.

Assuming the presence of an oil reservoir under the downthrow of the lake depression there are two main possibilities: (1) It is in the argillites, in which case its continuation, or another, may be looked for on the land; or (2) it is in some other bed above the argillites which has been faulted down beneath the lake.

The apparently inhospitable nature of the argillites as far as petroleum is concerned in this part of the country has been demonstrated ; and until quite recently no facts were known which might be taken to indicate the presence below the lake of beds other than the much-faulted argillites. But a short while ago some fragments of fossil bone reached the office of the Survey. They were said to come from the escarpment to the south-west of the lake. There is little doubt that they belong to post-argillite times, and, indeed, they suggest Miocene. The important role which Miocene deposits have played as oil reservoirs in various parts of the world is well known, and although the proof of the Miocene age of the fossils would not in itself go very far to solve the problem of the Lake Albert oil, it would be highly suggestive ; and in any case the study of the geology of the beds from which they come is a matter of great importance in this connexion. The Lake Albert region is a critical one, because if it can be shown that the oil (payable or otherwise) is seeping from the argillites, considerable possibilities will be opened up, for in Uganda the argillite series is very extensively represented and places are known where it presents much more hopeful facies than it does near Lake Albert.

It might be thought that too much stress has been lain on the anticline or dome as an essential oil structure ; such, however, is probably not the case in this instance. Although it must be admitted that the anticlinal theory has been pushed too far, and that some oil reservoirs, at any rate, have been proved to bear to the geography of ancient shore deposits a relationship more definite than that to be expected of reservoir to trap-structures on the line of what was orthodox theory more than thirty years ago ; yet, in the absence of any known reservoir rock it is impossible to determine the local significance of any other trap or retardation structure in relation to petroleum. The discovery of so generally favourable a structure as a dome would not, in the circumstances, be considered of much value by experienced oil geologists, except for the purpose of purely experimental boring, and certainly nobody would dare to pronounce very hopefully upon it ; but the individual, company, or Government, willing to take a very "sporting" chance in the face of decidedly big risks must have something to go upon, and the best one can offer in the present connexion is a dome within an area supposedly petroliferous.

Some of the beds of the argillite series have proved on examination to resemble the Hospital Hill slates of South Africa in that they are highly siliceous. They may be regarded as generally ferruginous sandstones of exceedingly fine grain. Some of them are decidedly absorbent, so it is possible that a reservoir may be located among them. But this very fineness of grain renders small the probability of bringing in as producers any oil well sunk into such a reservoir. There is, however, the possibility that pressure may cause a fine-grained reservoir to express petroleum into fissures at depth, but it is not possible to estimate the quantity that fissures, thus supplied, will yield ; generally it may be regarded as low. None-the-less, if a petroliferous horizon can be located in the argillites a very important fact will have been established, because the argillites in some parts of the country contain sandstones and grits which might function admirably in the storage of petroleum. In this connexion it may be as well to call attention to a limestone, presumably a bedded one, discovered by A. E. H. Reid.

It must not be supposed that the rather discouraging results obtained up to date are in any way a justification for discountenancing further search, for such is far from being the case. The problem is not a simple one, and, as in most cases where the geology of the country is concerned, the necessary facts for its solution are largely hidden from view by a thick mantle of surface deposits and vegetation.

The possibility of petroliferous beds in the argillites is, by reason of their wide distribution, an attractive one, and it is believed that when this possibility is brought home to those in Britain who interest themselves in oil, it will be seriously considered and investigated by their representatives from the point of view of commercial enterprise.

MONAZITE.—This mineral is of very wide distribution, but only two localities are known where it occurs in quantity. One of these is conveniently situated with regard to transport and mining facilities, and in the event of the deposit proving sufficiently extensive the winning and marketing of the mineral may become a commercial proposition.

ZIRCON and THORITE are also reported in Uganda.

THE DIAMOND-DRILL IN OIL-BORING

In the *Engineering and Mining Journal* for January 7, J. S. Mitchell writes on prospecting for oil with the diamond-drill. This article is of timely interest in view of the results obtained in Mexico by this method. We quote from Mr. Mitchell's paper, and also follow with extracts from the *Tampico Tribune*.

In the past the average depth of holes was much less than it is to-day. As the depth of hole has increased the drilling equipment of the percussion type has been enlarged and strengthened to handle the greater load, but in most respects the standard or rotary rig has undergone little change. For depths up to 700 or 1,000 ft. in formations favourable for its use the percussion-type drill is more efficient than any other, but in very deep holes the cost mounts rapidly, due to the necessity of using casing not only to hold back caving material, but to cut off water when encountered. When water stands in the hole the blow of the tools is retarded through the cushioning effect and friction on the line. Where it is desired to carry a hole to a great depth the usual practice is to start with very large casing in order to provide for a number of lines to be set as conditions demand. When long, heavy lines of casing are necessary and the working strains are greater, more accidents occur, resulting in considerable delay and expense in fishing for casing or lost tools.

Deep work called for expenditures that could only be provided by strong companies, and these companies, realizing that their future depended on new fields to take the place of depleted territory, are building organizations for conducting exploration work on a large scale. For much of this work in unproved fields the diamond-drill has the advantage over other types as it is a much lighter outfit and produces a core of all solid material penetrated. It is possible with the core to identify the various strata beyond a doubt, thus determining whether or not the hole is in favourable formation and at what point oil would be reasonably expected. Diamond-drill holes of from 4,000 to 6,000 ft. in depth are not uncommon, and the possibilities of trouble in drilling great depth is not increased in the same ratio as with cable tools, neither does the weight of outfit for greater depth increase in the same proportion. This is an important consideration, particularly in remote districts. A cable rig equipped with casing for a depth of 3,000 ft. weighs from 125,000 to 250,000 lb., depending on the formation. In the fields south of Tampico, Mexico, rotary outfits with cable equipment have amounted to 250 tons. Moving this amount of equipment through rough country and drilling one prospect hole 2,500 ft. deep means an outlay of around $150,000 for operating costs.

A diamond-drill outfit complete for a hole of the above depth will weigh from 50,000 to 60,000 lb., and if equipped with sectional boilers may be knocked down for handling on mule back. In principle the diamond-drill resembles the rotary drill more than the standard rig. Hollow flush coupling rods are used and the drill itself is a self-contained unit so arranged that the rods are rotated and raised or lowered by a hydraulic cylinder acting direct from the line of rods. The hoist is also an integral part of the machine. In the larger size both the hoist and the hydraulic feed cylinders are capable of handling from 30,000 to 40,000 lb. of drill rods. When drilling at great depth all excepting about 900 ft. of rods is carried by the hydraulic cylinder and at no time is the full weight permitted to rest on the diamond bit. The rotating speed averages around 250 revolutions a minute and the feed from 5 to 8 feet per hour, while drilling solid rock. In soft material a fish-tail bit and mud fluid are used the same as with the rotary. The drilling speed or rate of advance in loose material is somewhat less than the rotary, but the speed in hard rock is greater than either the cable or rotary rigs, and the harder the rock, the greater the advantage in cutting with diamonds.

The initial cost of diamonds is high, but the cost per foot of drilling is comparatively small. The bit usually consists of eight stones, weighing from 2½ to 3 carats each. The best grade, which is the most economical to use, sells at $125 per carat, making a cost of from $2,500 to $3,000 for the bit. The per foot cost for diamonds in ordinary oil formation averages between 25 c. and 30 c.

One criticism of the diamond-drill in oil work that is often made is that it does not drill a large hole. There is no mechanical reason why it cannot drill a large hole, but in prospecting or drilling to locate oil, a 2 in. core from a 3 in. hole will give as much information on geological conditions as a large hole, and will give far more information than the non-coring type of drill, regardless of size of hole. Drilling a larger hole would call for larger and heavier equipment, which is unnecessary when it is desired to prospect with a view to locating an oil pool rather than prepare for a larger production. In exploration work the important thing is to locate oil. The diamond-drill is primarily intended for work of this kind, and particularly well adapted for it, as it furnishes absolutely accurate data of underground conditions at a minimum cost.

Some of the diamond-drills now on oil drilling are equipped with fittings for 4 in. casing and drilling in with 3⅝ in. bit, although this is not the maximum size that may be used. It is large enough to take care of considerable production. The production of the majority of wells can be handled easily through a 4 in. pipe. In the Mexican field where pressures are high a 4 in. pipe will take care of from 25,000 to 50,000 barrels of oil per day, depending on depth, temperature, percentage of gas, and viscosity. Just how much the size of pipe has to do with the production of the well is difficult to determine. In a pumping well there is little advantage in having a casing larger than necessary to take care of production. In a high-pressure well the size of casing will have some effect on production, but the amount of flow depends more on the porosity of rocks or capacity of channels leading to the point of contact with the casing. The friction in the larger casing is less, but if the flow to the casing is less than the capacity of the casing a smaller line will serve as well. If the size of casing determined the production of a well, an 8 in. well would produce four times as much as a 4 in. well, and this is certainly not the case.

One reason that it has been the practice to drill large wells is that neither the rotary nor the standard rig can drill a hole smaller than 6 in. efficiently, and with the standard rig it is necessary under some conditions to start holes 20 in. in diameter in order to provide for the necessary lines of casing to cut off water. Assuming a hole is enlarged at the bottom, a casing is simply a flow line to the surface, and there is no good reason why it should be larger than the surface flow line, except in pumping wells, where the casing must be large enough to operate the pump properly. One interesting feature of the diamond-drill is the method employed for controlling high gas or oil pressures when drilling or removing rods. An oil saver or packing box is provided with a series of cup leathers designed for high pressure. The rods, having flush joints, pass through the packing box, making a safe, tight joint to take care of any pressures that may be encountered suddenly. When it is desired to remove the rods under pressure, a sheave wheel is attached to the top of the rods. The hoisting rope is passed through a sheave at the floor, then over the sheave on the rods, and the end of the rope attached to the floor on the opposite side of the machine. The rods are then allowed to rise under control of the hoisting brake and are removed in 10 ft. sections, being held by the chuck while each length is removed. With this arrangement it is possible to raise the bit to a point between the valve and the packing-box, after which the valve is closed, and the packing-box removed.

The *Tampico Tribune* for December 10 (to which reference has already been made) gives particulars of the results of drilling for oil by means of the Sullivan diamond-drill in the Mexican oilfields. The first producing oil-well ever brought in, in any field, with a diamond-drill, was successfully completed on December 4 on location No. 6, Ugarte tract, Buena Vista, by the Panuco-Boston Oil Company, a subsidiary of the Atlantic Refining Company of Philadelphia. The well came in at a depth of 2,153 ft., with an estimated production of 1,200 barrels daily. The completion of this well made drilling history, and the experiment was one of which the whole oil world will learn with great interest. To the Mexican oilfield its possibilities are tremendous, for the great expense of drilling wells there has been the greatest drawback to exploration, while the diamond-drill method will enable companies to test unproved territory at a fraction of the cost under the method generally in use. The diamond-drill also makes possible the keeping of an absolute log on every foot of rock pierced. In drilling this well an ordinary fishtail bit was used down to 1,400 ft., and the diamond-drill was used and the cores taken from that depth to completion. The hole drilled is 4 in. at the top and 3½ in. at the point of completion. While some difficulties were encountered in the use of the fishtail bit, they were defects in size and material, and not in method. No difficulties were encountered after straight diamond-drilling was started.

Vanadium in the Transvaal.—The *South African Journal of Industries* for December contains an article by Malcolm Fergusson and Dr. P. A. Wagner on the vanadinite deposits at Kaffirskraal, Marico District, Transvaal. It will be remembered that a year ago the same authors described similar lead-vanadium deposits at Doornhoek, south-east of Zeerust.

The vanadinite deposits at Kaffirskraal occur in the uppermost portion of the dolomite series, which in this part of the Transvaal has undergone considerable metamorphism, apparently as a result of the intrusion of the Bushveld laccolite. The actual country rock is soft-bedded manganese earth, which over an irregular and as yet imperfectly defined area has replaced the dolomite, but contains the contact minerals — principally talc and wollastonite—originally present in that rock. The manganese earth is regularly interstratified with shale, banded shale, shaly chert, and chert. The beds are disposed in the form of an anticline, the limbs of which dip approximately east to west. Numerous minor folds are superimposed on the main flexure, so that the beds follow a wavy course. Intersecting the dolomite series are two dykes of a highly altered igneous rock of intermediate composition. The smaller and more northerly of the dykes is vertical, has a W.N.W.-E.S.E. strike, and a width of about 10 ft. The other dyke situated 436 ft. to the south has so far only been exposed at two points, and its strike has not been definitely determined. It will probably prove, however, to be parallel with the first. It has a width of at least 90 ft., and is seen at one point to dip steeply toward the north. The principal vanadinite workings lie between these dykes, and the deposits are almost certainly connected genetically with them, those of the so-called Christmas section running roughly parallel with the smaller dyke. The vanadinite has been proved to extend beyond this dyke and may also extend beyond the southern dyke. In regard to the original nature of the dyke rock there is considerable uncertainty. It now consists of soft white pseudomorphs after crystals and laths of felspar set in a greyish clayey base. There are two apparently distinct vanadium-bearing areas separated by a stretch, approximately 135 ft. in width, in which no vanadinite has as yet been found. It is relevant to observe, however, that only one section of this stretch has been explored, and further investigation may prove the two areas to be continuous.

The vanadinite, in well-formed hexagonal crystals and in aggregates of such crystals, occurs in irregular layers conforming to the bedding of the manganese earth and associated rocks, in steeply inclined veins cutting across the bedding, in irregular pockets and vughs—the latter sometimes lined with quartz crystals—and, finally, as an incrustation on joint planes in shale and chert. In some sections of the deposits vanadinite is the only ore-mineral present. As a rule, however, it is intimately associated with other lead minerals, such as pyromorphite, cerussite, and galena. All these minerals have much the same specific gravity, and it would be impracticable even to attempt to keep them separate when working on a large scale, though it will doubtless be possible by hand-picking to remove much of the galena and pyromorphite. It was at one time thought that the presence of the pyromorphite might seriously detract from the value of the concentrates produced, but as a process has now been discovered for eliminating the phosphorus there is no longer ground for apprehension on this score.

The vanadinite is obviously of secondary origin, having doubtless resulted from the alteration of galena. Its formation and present distribution are to be attributed to the activity of descending oxygenated waters, the mineral being found wherever conditions were favourable to the circulation and damming up of such waters; for instance, along the bedding planes of the manganese earth and associated rocks in cavernous layers of chert, in joints and fissures at the contacts of the dykes already referred to, and in joints in these dykes. The area over which the mineral is distributed is in all probability much larger than that which contained the primary galena. The latter appears to occur mainly as an irregular replacement in layers of chert or cherty shale and also in steeply inclined veins and stringers cutting across the bedding and probably following what were originally joints in the unaltered dolomite. It is in places associated with white vein quartz. Much of the galena has been oxidized *in situ* to cerussite and pyromorphite, and it is not uncommon to find layers of one or both of these minerals encrusting a core of galena. Vanadinite is only rarely found in direct association with galena, but one part of the Christmas section workings yields magnificent specimens in which residual cores of galena are encased by concentric crusts of cerussite, pyromorphite, and vanadinite, the minerals being arranged in the order named, the vanadinite farthest from the galena.

In some parts of the deposit the galena is associated with pyrite, and the highly ferruginous nature of much of the ore-bearing material suggests that a considerable amount of pyrite was originally present. Some of the chert layers are crowded with small limonite-lined cavities that were once occupied by pyrite crystals.

The conversion of the dolomite to manganese earth appears to have taken place after the formation of the galena-pyrite deposits, and the development of the vanadinite and pyromorphite after the alteration of the dolomite through the agency of the manganese-bearing solutions, as vertical and steeply inclined bodies of vanadinite ore are in places seen to cut across the layers of manganese earth. The formation of vanadinite, cerussite, and pyromorphite is without doubt still in progress at the present time.

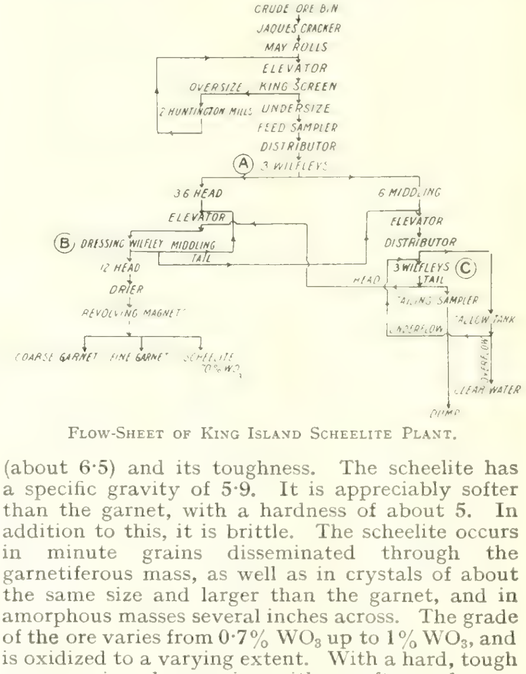
There are two workings, about 100 yards apart, known as the Incline Section and the Christmas Section respectively. The available data do not suffice for an accurate estimate of the amount of ore developed in the Incline Section, but the authors have endeavoured roughly to arrive at the tonnage from the following data. The area over which the vanadinite may be assumed with reasonable certainty to extend is 7,900 sq. ft. Twelve representative samples have been taken in different parts of the three blocks developed. These show from 0·27 to 3·79% of vanadium over widths varying from 12 in. to 162 in. The average works out at 1·76% of vanadium, equivalent to 3·14% V_2O_5, over 75 in. As the samples were not equally spaced, this does not represent a true average, but it is probably a fairly close approximation. Using these figures and assuming that 15 cu. ft. of the ore go to a ton—which is probably much too high—this would give 3,330 tons of ore, averaging 3·14% of V_2O_5. Conditions throughout the block are favourable to cheap mining, the average thickness of overburden being only about 10 ft. The ore is readily amenable to concentration. It should be possible, therefore, without much difficulty to recover most of the vanadium contained in this section at a relatively low cost.

In the Christmas Section forty-one samples have been taken. These show from 0·04 to 3·44% of vanadium over widths varying from 6 in. to 162 in. The average works out at 1·056% of vanadium, equivalent to 1·884% of V_2O_5 over 50 in. With the same reservations as before this gives 1,748 tons averaging 1·884% of V_2O_5.

King Island Scheelite.—The *Proceedings* of the Australasian Institute of Mining and Metallurgy, No. 43, 1921, contains a paper by Herbert Lavers on the tungsten deposits on King Island, situated off the north-west coast of Tasmania. These deposits were developed by the King Island Scheelite Company, which was financed by the Broken Hill Block 14 Company, and was formed in 1917. The ore of tungsten is scheelite, tungstate of lime, and the gangue consists largely of garnet.

Both igneous and sedimentary rocks are represented in the neighbourhood of the mine; the latter occupy the bulk of the area of the property, the south-eastern corner of which is on the contact of the granite and sedimentary rock. Granite outcrops for 7 or 8 miles along the coast to the south of the mine, and appears to extend inland for at least 2 miles. Old slates and sandstones extend to the north for some distance. The granite, which is of the porphyritic biotite type, is very fresh, and shows no signs of crushing. At the contact, granite-porphyry occurs, with occasional large crystals of pink orthoclase felspar. It is traversed by occasional dykes of granite-porphyry and of aplite, representing, probably, later phrases of the igneous intrusion. Closely associated with the scheelite lode is a dyke of aplite, undoubtedly connected with the granite. It is composed essentially of quartz, with some decomposed felspar and aggregates of muscovite-mica. It carries both molybdenite and scheelite in places.

The scheelite occurs in the sedimentary rocks, but within about 12 chains of the margin of the granite massif. As is to be expected in such close proximity to the intrusive granite mass, the old sedimentary rocks are intensely altered. They appear sometimes as spotted schists, sometimes as very hard, black, flinty hornstones. Microscopical examination of sections of these rocks shows the development of quartz, albite, sericite, chlorite, biotite, and magnetite. The gangue consists essentially of garnet, usually in well-formed crystals. Other gangue minerals are quartz, epidote, calcite, monoclinic pyroxene, and actinolite. The metallic minerals are scheelite, molybdenite, pyrite, and bismuth. The variety of garnet is of the lime-iron type, known as andradite. It is usually reddish in colour, and translucent, and occurs in well-formed crystals up to about ¼ in. across. The garnet is attracted by the electro-magnet, and this property at once suggested a possible method of treatment. The average specific gravity of the garnet is 3·7. Its other outstanding features are its hardness



FLOW-SHEET OF KING ISLAND SCHEELITE PLANT.

(about 6·5) and its toughness. The scheelite has a specific gravity of 5·9. It is appreciably softer than the garnet, with a hardness of about 5. In addition to this, it is brittle. The scheelite occurs in minute grains disseminated through the garnetiferous mass, as well as in crystals of about the same size and larger than the garnet, and in amorphous masses several inches across. The grade of the ore varies from 0·7% WO_3 up to 1% WO_3, and is oxidized to a varying extent. With a hard, tough gangue mineral occurring with a softer and more brittle mineral to be concentrated, the object is to remove the scheelite at the earliest convenient stage in order to minimize slime losses. The relatively small difference in specific gravity between the garnet, other gangue, and scheelite indicates the necessity for careful classification in order to obtain a satisfactory concentrate. From experiments carried out at an early stage in the development of the mine it was found that the garnet had a certain magnetic permeability, and was, moreover, the only magnetic mineral in the ore. The scheme of treatment adopted was as follows: Coarse crushing, tabling to remove such gangue minerals as quartz, aplite, etc., and the formation of a garnet-scheelite concentrate; this mixed concentrate to be passed under an electro-magnet to remove the garnet, leaving a marketable product of high-grade scheelite.

The ore is hand-fed direct from the bin to a Jaques cracker, which has ample capacity for the present tonnage of comparatively soft oxidized ore. From the cracker the ore goes to May rolls, the oversize of which is further treated in Huntington mills. The rolls and Huntington mills are in closed circuit with a King screen. The mills are carefully regulated to release the scheelite at the earliest moment, in order to make as little fines as possible. Three Wilfleys shown at (A), take the feed from the King screen, and make two products, a head which goes to a redressing Wilfley (B), and a middling which goes to three Wilfleys (C). Wilfley (B) produces a scheelite-garnet concentrate of about 45% WO_3, which is dried and passed under the electro-magnets. A middling product is returned to the same table, and a tailing to the tables (C) for further treatment. The Wilfleys (C) thus re-treat a middling from tables (A) and a tailing from the re-dressing tables (B). They also treat an underflow from a Callow settler, which catches the slime from the overflow water. They produce a middling product which is returned to table (B), and a tail, the only reject from the mill, which runs into the sea and is dispersed by wave action.

The scheelite-garnet concentrate, from the re-dressing table (B), is run into a box, from which it is shovelled on to one end of a drying furnace. The concentrate is gradually worked to the cool end of the furnace and then hand-screened, to remove any large particles which may have escaped the King screen. These particles are returned to the Huntington mill. The drier is heated by means of firewood, the consumption of which is small. The screened concentrate is then bagged and transferred to the electro-magnets. These consist of two revolving magnets operating over an endless belt, beneath which are the wound and insulated poles. The magnets are hung on ball bearings, and driven by spur gearing at 40 r.p.m. The diameter of the magnets is 22 in. and they have a depth of 4 in. The belt is of fine canvass, and before use undergoes a special treatment of oiling and drying, followed by a coat of shellac varnish. The belt passes over 12 in. drums, the rate of travel being 27 ft. per minute. The concentrate is fed from a hopper by means of a roller feed. The air-space between the magnets and belt is so arranged that a coarse and fine garnet product is removed in two stages, and leaves on the belt a scheelite concentrate containing about 70% WO_3. This is carried over the end of the belt, where it is bagged, weighed, and sampled. The garnet extract is returned to the mill as a protection against faulty work, which may be due to excessive feed to the magnets or incomplete drying of the mixed concentrate. The current supplied to the magnets is at 240 volts.

For the six-monthly period ended March 31, 1920, 15,823 tons of ore was sent to the mill for treatment, averaging 0·67% WO_3, which produced 121 tons 7 cwt. of concentrate, averaging 69·6% WO_3, representing a recovery of 79·5%.

Recovery of Zinc from Cyanide Plants.—The *South African Journal of Industries* for December contains a description of the Kominsky process for recovering zinc from waste solutions from cyanide plants. This process is in work on a small scale at Germiston, east of Johannesburg. The zinc-slimes obtained in the precipitation of gold from cyanide solutions consist of metallic gold in finely divided form, unattacked zinc, and some insoluble zinc compounds. After the mass has been filtered the solid mass is treated with sulphuric acid solution or with a solution of acid sodium sulphate. The gold remains unchanged by this treatment, but the zinc passes into solution. After the treatment with acid is completed, the gold is separated and sent to the smelting-house. The solution contains zinc in solution, and is at present run to waste. The object of the Kominsky process is to obtain the zinc in the form of pigment. The solution contains, as a rule, zinc salts equivalent to about 5% of metallic zinc, but, in addition, it always contains a small amount of iron salts which are present mostly in the ferrous condition, and the solution is always acid. For the production of zinc pigment it is necessary to remove the iron from the solution, because if this is not done the iron would find its way into the precipitated zinc compounds and would cause discoloration. The removal of the iron has been made possible by the Kominsky process. At the Germiston works the first step in the process is the control of the acidity of the solution; if the solution is too acid the acidity is reduced by the addition of lime, but care must be exercised that the acidity is not reduced too much. The iron in the solution is then completely converted into ferric condition by the addition of a solution of sodium chromate. As the ferrous iron is oxidized to the ferric state the chromate (or bichromate, since the reaction takes place in slightly acid solution) is reduced so that the solution now contains, in addition to sodium salts, zinc sulphate, ferric sulphate, and chromium sulphate. It is not advisable to use excess of sodium chromate, although a moderate excess can readily be corrected. To a small proportion of the original solution the requisite quantity (but no excess) of solution of sodium hydroxide is added. This precipitates impure zinc hydroxide. This zinc hydroxide is made into a thin paste, which is now added to the fully oxidized solution. The zinc hydroxide is added in considerable excess. The first action is that of the excess of acid present on the suspended zinc hydroxide, whereby the solution is neutralized and a quantity of zinc sulphate equivalent to the free sulphuric acid present is produced and passes into solution. The zinc hydroxide then reacts in the neutral solution with the ferric and chromium sulphates, producing insoluble ferric and chromium hydroxides, which separate from the solution and an equivalent quantity of zinc sulphate passes into solution. The fluid is then filtered, and the clear filtrate obtained is a neutral solution of zinc sulphate and sodium sulphate. The sludge in the filter-press contains an excess of zinc hydroxide mixed with hydroxides of iron and chromium, and can be re-used as a precipitating agent until the zinc hydroxide is almost exhausted. The clarified solution containing zinc and sodium sulphates is now in a condition to be precipitated. The precipitation may be effected by means of a solution of sodium carbonate whereby insoluble (basic) zinc carbonate is deposited, or by means of solution of sodium chromate, in which case insoluble zinc chromate separates. The insoluble zinc salt is well washed with water to remove all the sodium salts, and it is then separated in a filter-press. The sludge in the filter-press is dried; at present the sludge is dried by exposure to the air, but this method is unsatisfactory and a dust-proof drier should be installed. The dried zinc chromate obtained in this way requires only to be crushed and sieved to be ready for use as a pigment, zinc yellow. In order to make zinc white (zinc oxide) the dried basic carbonate would require to be calcined in a calcining furnace, and in order to make a satisfactory pigment the calcined mass would require to be finely ground and sieved. The processes in use at the Germiston works are simple. The present capacity of the plant allows of the production of about 2⅓ tons of pigment per day of twenty-four hours. The cost of the process will be determined largely by: (*a*) transport of the zinc-slime solutions to the works; (*b*) cost of reagents, sodium chromate, and sodium carbonate. There will be obtained as a by-product sodium sulphate in the form of a solution. Recovery of this salt (Glauber salt) in a useful form will entail evaporation or a system of evaporation followed by refrigeration. It may be added that, on the assumption that the zinc-slime solution obtained from the gold mines contains zinc salts equivalent to 5% of metallic zinc, each gallon of the solution would contain ½ lb. of zinc, and from this would be obtained 1·38 lb. of zinc chromate (zinc yellow) with the aid of 1·25 lb. of sodium chromate. Or, if zinc white (zinc oxide) were made, then for each gallon of solution 0·81 lb. of sodium carbonate would be required and 0·96 lb. of zinc carbonate would be obtained, which would yield 0·62 lb. of zinc white. The consumption of zinc on the gold mines of the Witwatersrand is about 2,500 tons per annum. The major portion of this amount can be recovered.

History of Blast-Roasting. — In *Mining and Metallurgy* for December, Arthur S. Dwight contributes a paper on the evolution of mechanical roasting. He gives the history of mechanical roasting furnaces in Colorado and Montana, as applied to lead and copper ores respectively, and proceeds to tell how the furnaces were found to have many disadvantages as compared with hand-operated furnaces when applied to lead ores, subsequently showing that the principle of blast-roasting came to the rescue of the mechanical method of treatment. He mentions an early effort to apply the principle of blast-roasting. When, in 1897, he assumed general charge of the Arkansas Valley plant, then one of the branches of the Consolidated Kansas City Smelting & Refining Co., there was in operation a Brückner, equipped after a plan devised by Rhodes & Kloz, with a perforated tile lining through which air currents were caused to stream while that part of the lining was under the talus of ore during a portion of the revolution. Much was hoped for from this plan. The character of the product was distinctly better; being coarser than the ordinary Brückner roast. It made more flue dust than others, and was wasteful of air-blast by reason of the uneven thickness of ore over the air ports, the thicker centre of the ore-talus blocking the air currents, and the thin edges favouring them, which was the reverse of efficient. It was finally abandoned, about 1898, after a fair trial.

The present era of blast-roasting in America began about 1902 or 1903, when the Huntington-Heberlein process of pot-roasting began to be known in that country, and to be made the subject of experimentation. Though the original H. & H. patent in England bears date of 1896, that was not the real beginning of the art, and, indeed, it is rather difficult to decide when the first attempts along this line were made. To the veteran metallurgist, James W. Neill, great credit is due for having applied the principle of intensive roasting with an air-blast, in a manner that was relatively successful, highly interesting, and undoubtedly suggestive to other metallurgists. He treated a small quantity of matte by such a method at Mine La Motte, Missouri, in 1883. In 1889, at the Harrison Reduction Works, Leadville, having no roasting plant, he rigged one of his idle blast-furnaces as an updraft blast-roasting hearth and used it to roast several hundred tons of ore. This roaster suggested the construction of the Williams roaster, which was built the following year at the Arkansas Valley smelter, next door, and which departed only in small details from its prototype. The Williams roaster was still in existence when the writer took charge in 1897, but had not been used for several years, and was out of repair.

In 1894 or 1895 Neill built a battery of blast-roasting furnaces of his own design at the Yampa smelter in Bingham Canyon, Utah. They were simple kilns with horizontal grates and up-draft. They were successful in that they met the commercial condition for which they were installed, and ran continuously until a change of smelter rates shut down the plant, a considerable tonnage having been treated in the meantime. About 1900 this equipment was sold to the Great Falls plant of the Boston & Montana for experimental purposes. R. L. Lloyd, who afterwards became the writer's associate, was at that time general foreman of the Great Falls plant, and it fell to his lot to conduct the experimental work. Over 1,000 tons of concentrates were treated under his direction, but the procedure was abandoned because the process was slow and expensive, and was very hard on the men, on account of the choking gases that could not be controlled. Nevertheless, it contained the germ of a valuable idea, and it was a contemplation of the faults and virtues of this device of Neill's, in connexion with the other blast-roasting devices then known, which led up to the idea of the Dwight and Lloyd process, which by the addition of a new principle succeeded in substituting, for the more or less haphazard conditions that prevailed in the Neill and the other existing processes, a precise regulation of the principal factors that controlled the turning out of a predetermined product, of uniform character, which overcame the smoke trouble, and which made a continuous process of it.

The American Smelting & Refining Co., after building some trial plants of Huntington-Heberlein pots, decided about 1904–05 to purchase the H. & H. patent rights for the United States, and most of their western plants were equipped with batteries of pots, in connexion with which Godfrey furnaces were installed to effect the preliminary roast. The Godfrey is a circular furnace with a revolving hearth, carrying the layer of ore against stationary rabble blades projecting down through the roof. The Savelsberg process, a variation of the pot-roasting processes, using crushed limestone as a diluent in place of the burnt lime of H. & H., dispensed with the pre-roast. The St. Joseph Lead Co. installed a large Savelsberg plant at its works at Herculaneum, Missouri.

From the moment that the A. S. & R. Co. adopted the H. & H. process, the doom was sealed of that ancient standby of the lead smelter, the hand-roaster, and as fast as pot-roasting capacity could be provided to take their place, hand-roasters and Brückners were abandoned. The pot product was greatly superior to that of either of these, and the economy in operating may be judged from the fact that the efficiency factor of the pots (averaging about 625 lb. per sq. ft. hearth area per day) was five times as great as that of Brückners (125 lb.), and fully twenty-five times that of the hand-roaster. The rather rapid growth of H. & H. plants in the United States was suddenly checked in 1907, when the first Dwight & Lloyd machine was installed at the Perth Amboy plant of the A. S. & R. Co., and demonstrated conclusively that, besides having certain other important advantages, such as superiority of product, healthfulness of working conditions, and low operating costs, it had an efficiency factor of over 3,000 lb. per sq. ft. per day, or 5 times as great as the pots, 25 times as great as the Brückners and the mechanically rabbled furnaces, 125 times as great as the hand-roasters, and 625 times as great as the primitive roast-heaps. After 1908 there were no more pots installed in the lead plants of the United States, the D. & L system came to be accepted as standard practice, and all further additions and new installations were of that kind. Some of the pot plants were scrapped, but some then in existence have continued to run until now.

Losses in Silver Refining. — In *Mining and Metallurgy* for January, G. H. Clevenger, F. S. Mulock, and G. W. Harris gave an account of investigations into the losses by volatilization and dusting during the melting of cyanide precipitate and in the air-refining of bullion at the Real del Monte silver mine, Pachuca, Mexico. Zinc-dust precipitation is employed at the Loreto and Guerrero mills of the company. The Loreto precipitate averages 75 to 78% silver and gold and the Guerrero precipitate 80 to 85%. The melting furnaces are at the Loreto mill and the Guerrero precipitate is taken there in special locked steel containers. The precipitate from each mill is melted separately and the by-products, so far as possible, are segregated. The precipitate as charged to the furnaces contains 30 to 35% moisture. The melting equipment consists of two ordinary oil-fired reverberatory furnaces with firebrick bottoms. The regular procedure in melting the precipitate is to pre-heat the furnace ; then a charge of precipitate, roughly mixed with the minimum amount of flux, consisting of borax glass and finely ground bottle glass, is shovelled by hand from shallow charge cars through the work door at the burner end of the furnace. After the first charge has melted, additional charges are added until the desired amount of bullion has collected on the hearth. The furnace is then tapped, and the bullion cast directly into moulds carried on a special casting machine. In cases where the bullion is air-refined the desired number of charges are melted and the slag is tapped from the top of the bullion, the last of it being skimmed with a rabble and pulled through the work door. After removal of the slag, air-refining proceeds. It has not been the practice heretofore to air-refine, since there was no advantage in doing this when outside refineries did the final refining, but now that the company is to have its own electrolytic refinery, it has become a matter of importance to ascertain to what extent this cyanide bullion is amenable to air-refining. It is generally recognized by refiners that it is desirable to eliminate base metals so far as possible by furnace-refining prior to electrolytic refining. The tests of which an account is given in this paper were made, therefore, not only to determine dusting and volatilization losses, but also to determine the extent to which this cyanide bullion could be air-refined.

The authors proceed to describe the apparatus whereby the tests were made, and then give tables and analyses of results. The losses are surprisingly small when it is considered that the precipitate is melted in reverberatory furnaces without briquetting. The average loss of silver is 0·1074%, and of gold 0·02805%, for the Loreto precipitate during melting. The average loss of silver is 0·0625%, and of gold 0·0150%, for the Guerrero precipitate during melting. The average loss of silver is 0·0497%, and of gold 0·0133%, during air-refining of Loreto bullion. The average loss of silver is 0·0156%, and of gold 0·00387%, during air-refining of Guerrero bullion. The loss of both silver and gold is considerably greater during the melting of the precipitate and the air-refining of the bullion with Loreto precipitate than with Guerrero precipitate. The ratio of silver loss of Loreto to Guerrero for the whole of the precipitate melting period is 1·72 to 1 and the ratio of gold loss is 1·81 to 1. Taking the average hourly losses, the ratio for silver is 1·37 to 1 and for gold is 1·54 to 1. The ratio of silver loss of Loreto to Guerrero for the whole air-refining period is 3·2 to 1 and the ratio of gold loss is 3·44 to 1. Taking the average hourly losses, the ratio for silver is 4·03 to 1 and for gold is 4·22 to 1. This difference is sufficiently consistent to preclude its being due to experimental error or variation of conditions in the furnace. The authors are unable to give a definite reason for this phenomenon, but it is of significance that the Guerrero precipitate contains more lead and copper than does the Loreto precipitate. The authors also have evidence indicating that certain base bullions show less loss by volatilization during melting and holding a charge of molten metal in the furnace than does refined silver. The effect of lead upon the amount of silver carried over in the distillation of the zinc crusts from the Parkes process has been studied by F. P. Dewey, who says that lead protects the silver from the drag of the volatilizing zinc.

Frary Alloys. — *Chemical and Metallurgical Engineering* for December 28 reprints a paper by W. A. Cowan, L. D. Simpkins, and G. O. Hiers, read before the September meeting of the American Electro-Chemical Society, on the electrolytic production of calcium-barium-lead alloys, invented by F C. Frary and S. N. Temple. As has been recorded in our pages on several occasions, Mr. Frary has made a special study of calcium for many years, and has produced calcium-lead alloys, which are suitable for use as bearing metals in machinery. The high price of tin and the irregularity in the supplies of antimony during the war encouraged the further development of these alloys, and they are now made on an extensive scale by the United Lead Company, Keokuk, Iowa.

The method of production consists of electro-deposition from fused salts, and consists in electrolysing the fused chlorides of barium and calcium over a bath of molten lead as cathode. In the preparation of alloys of barium and calcium by this method the electro-deposited metals are taken up by the lead and the resulting alloy is obtained as the desired product. Owing to the difficulties in producing pure metallic calcium free from chlorides, carbides, and other impurities, it is not economical to produce an alloy by first preparing the calcium separately and adding it to molten lead. There would also be trouble in commercial manufacture of an alloy by mixing the pure metals in this way owing to the difficulty of obtaining complete solution of the calcium in the lead without loss by oxidation of the calcium. In attempting to produce metallic barium electrolytically it has been found that the resulting barium gathers around the cathode in droplets, which fail to coalesce, and therefore it is not economical to attempt to obtain the barium in a pure metallic state. However, with the use of a bath of molten lead as a cathode, this difficulty is not encountered, since the barium alloys readily with the lead as it is produced.

The process of manufacture, as carried out by by United Lead Co., consists in the use of a series of iron pots of about 2 tons capacity each. These are partly filled with pig lead of high quality. Each pot of the series is set in brickwork containing a hearth which is fired with coal. After the pots have been filled with pig lead all the hearths are fired until the lead is melted. On top of the molten lead is placed a layer of mixed calcium and barium chlorides of high purity, in such proportions as to give a low melting point. This layer of chlorides is usually about 3 or 4 in. thick. Each pot is equipped with a graphite anode at the centre, which can be raised or lowered by a chainblock. In starting the anodes are inserted in the chlorides and a direct current thrown in. There is sufficient resistance in the salts to produce enough heat to fuse the mixed chlorides. The temperatures in the pots are controlled by raising or lowering the anodes. Under the influence of the electrolytic action, the fused salts are decomposed and the resulting calcium and barium are absorbed by the molten lead. There is a tendency toward fogging and arcing, and considerable amounts of the calcium and barium form carbides which reduce the efficiency of the process, therefore requiring approximately three days of electrolysis to produce a lead alloy containing 2% of the alkaline earth metals. The fused chlorides and carbides tend to freeze at the surface, forming a hard crust, particularly around the periphery of the interior of the pots. If this forms too near the anode it may need to be broken down in order to give proper conditions; otherwise it is advantageous, acting as an insulator and thus preventing loss of current which might pass through the fused electrolyte from the anode directly to the iron pot instead of to the molten lead. When the proper amounts of calcium and barium have been absorbed by the lead, the current is shut off and the molten alloy is run out from the bottom of each pot into a carrying ladle of equal capacity, which is conveyed by an overhead crane. By this means the metal from the whole series of pots is emptied into a large mixing kettle, where it is thoroughly agitated and further alloying ingredients are added. The resulting alloy is then sampled and cast in water-cooled ingot moulds. The alloy thus produced by the United Lead Co. has been termed "Frary metal." As disclosed by the patents, it is essentially a ternary alloy of lead, barium, and calcium, with the addition of small amounts of other elements. It contains up to 2% barium and up to 1% calcium, the remainder consisting almost entirely of lead. As much as 0·25% mercury and smaller amounts of other elements may be added.

The United States patents covering these alloys and their manufacture are: 1,158,671-5 (Frary and Temple); 1,360,339 (Wettstein); 1,360,348 (Worrall); and 1,360,272 (de Camp).

SHORT NOTICES

The Quimby Pump.—*Engineering* for December 30 describes a high-lift rotary pump invented by W. Quimby, Newark, New Jersey.

Liquid-Air Explosives.—The *Iron and Coal Trades Review* for January 6 describes the Weber cartridge for holding liquid-air explosive.

Surveying Instruments.—The January *Bulletin* of the Institution of Mining and Metallurgy contains a paper by W. E. Whitehead on theodolites, used and proposed, for taking steep sights in mine shafts.

Grinding Mills.—In the *Engineering and Mining Journal* for December 17, G. J. Young discusses the relative advantages of the various methods of driving grinding mills.

Concentration at Catemou.—In the *Mining and Scientific Press* for December 24, F. Benitez describes the concentration methods at the Catemou copper mine, Chile.

Concentration of Lead Carbonate. — In the *Engineering and Mining Journal* for December 31, F. M. Heidelberg describes the concentration of lead carbonate ore at Santa Barbara, Chihuahua. Concentration is done on Deister tables, and there appears to be an experimental flotation plant for the slime tailing.

Flotation Plants.—In the *Mining and Scientific Press* for December 3, A. B. Parsons gives particulars of the main points in the design of notable plants in which the flotation process is employed.

Flotation of Coal.—The *Iron and Coal Trades Review* for December 30 gives a brief illustrated description of the Minerals Separation flotation plant, erected by the Skinningrove Iron Company, Yorkshire, for cleaning fine coal. The same paper for January 6 gives particulars of the coke made from this purified fine coal.

Broken Hill Steel Works.—The *Iron and Coal Trades Review* for January 13 contains an illustrated description of the Broken Hill Proprietary's iron and steel works at Newcastle, New South Wales.

Aluminium.—The *Proceedings* of the Royal Society, A. 100, 1921, contains Professor H. C. H. Carpenter's paper on the production of large crystals of aluminium by certain methods of heat treatment.

Producer-Gas Power-Plant.—At a meeting of the Institution of Mechanical Engineers held on January 20, H. S. Denny and N. V. S. Knibbs presented a paper entitled: "Some observations on a Producer-Gas Power-Plant."

Morocco.—The *Engineering and Mining Journal* for December 24 publishes an article by J. P. Hutchins on travels in Morocco.

H. F. Marriott.—The *Engineering and Mining Journal* for December 31 publishes an illustrated biographical notice of Hugh F. Marriott.

RECENT PATENTS PUBLISHED

☞ *A copy of the specification of any of the patents mentioned in this column can be obtained by sending 1s. to the Patent Office, Southampton Buildings, Chancery Lane, London, W.C. 2, with a note of the number and year of the patent.*

15,516 of 1920 (172,046). THERMAL INDUSTRIAL AND CHEMICAL RESEARCH CO. and J. S. MORGAN, London. For the purpose of detinning tinplate, immersing it in a bath of molten lead or tin and thus melting the tin, then immersing it is an "anti-flux" such as caustic soda, and finally immersing it in the bath of molten metal once more, when the tin will be removed from the plate.

19,388 of 1920 (147,470). F. D. S. ROBERTSON, Toronto. In the production of sublimated metallic oxides from sulphides, a method of regulating and using the currents of oxidizing gases. This invention relates particularly to the production of molybdenum oxide from molybdenite.

20,367 of 1920 (148,420). GESELLSCHAFT FÜR NAUTISCHE INSTRUMENTE and E. ALBRECHT, Kiel. Method of keeping vertical the bore-holes used in sinking shafts by the freezing method.

20,524 of 1920 (148,541). SPRENGLUFT GESELLSCHAFT, Charlottenburg. A vacuum-jacketed vessel for holding liquid-air explosives or cartridges.

22,459 of 1920 (172,356). JACKSON & Co., Valparaiso. Improved process for making the constituents of complex ores more amenable to leaching by moistening with nitrate and then heating.

22,672 of 1920 (172,067). G. JOHNSTON, Ulverston. In crushing rolls means for delivering the material to the rolls at a speed equal to the peripheral speed of the rolls, with the object of eliminating abrasive wear on the rolls.

24,659 of 1920 (173,268). Q. MARINO, London. Method of forming an electrolytic deposit of nickel or copper, or their alloys with silver or tin, upon metallic surfaces from cyanide solutions.

25,374 of 1920 (172,390). D. P. HYNES, Chicago. Improvements in froth-flotation machines, particularly in respect to the production of froth by mechanical means.

25,652 of 1920 (172,411). H. F. ERIKSSON, Nora, Sweden. Furnace for reducing iron ores in which electric current is employed for supplying part of the necessary heat, the reduction being done by a small proportion of coke and with carbonic oxide.

25,723 of 1920 (172,412). A. M. FOTHERINGHAME, Glasgow. A combined magnetic compass and dip indicator.

25,888 of 1920 (172,712). GENERAL ELECTRIC Co., Schenectady, New York. Improved form of boilers for vapourizing mercury, used to drive a turbine or other prime mover.

26,627 of 1920 (155,805). METALLBANK UND METALLURGISCHE GESELLSCHAFT, Frankfurt-am-Main. Improved method of introducing magnesium into aluminium for the purpose of making the alloy.

28,139 of 1920 (173,337). E. E. NAEF, Nottingham. Method of precipitating certain metals from their sulphides by melting with caustic soda at a temperature of 300 to 500° C.

28,747 of 1920 (152,335). SPRENGLUFT GESELLSCHAFT, Charlottenburg. Fuses for use in connexion with liquid-air explosives.

29,532 of 1920 (152,667). RHEINISCH-NASSAUISCHE BERGWERKS UND HÜTTEN GESELLSCHAFT, Stolberg. Mechanical roasting furnace having a number of superposed roasting chambers which consist of alternate stationary hearth plates and rotary hearths adapted to be rotated from the periphery, characterized by the fact that the individual hearth plates are operated by separate and independent driving means.

32,028 of 1920 (155,572). R. SEIFFERT, Berg-Gladbach, Germany. Modifications of zinc retorts with the object of producing larger proportions of zinc dust.

1,207 of 1921 (157,296). W. BREIL, Essen. Method of constructing iron shaft-linings in wet ground.

4,307 and 10,296 of 1921 (172,243 and 172,569). G. H. T. RAYNER and P. RAYNER, Sheffield. Improvements in valve apparatus of rock-drills.

NEW BOOKS, PAMPHLETS, Etc.

☞ Copies of the books, etc., mentioned below can be obtained through the Technical Bookshop of *The Mining Magazine*, 724, Salisbury House, London Wall, E.C. 2.

Up Against it in Nigeria. By LANGA LANGA. Cloth, octavo, 250 pages, illustrated. Price 18s. net. London: George Allen & Unwin, Ltd.

Tutorial Land and Mine Surveying. By THOMAS BRYSON. Cloth, octavo, 190 pages, illustrated. Price 10s. 6d. London: Sir Isaac Pitman & Sons, Ltd.

Fuel in Science and Practice. Edited by Professor R. H. WHEELER and Dr. J. V. ELSDEN. A new journal of the scientific and economic use of fuels, being the record of the Coal Research Club. This journal is to be published monthly as a supplement of the *Colliery Guardian*. The first number includes articles by S. R. Illingworth, of the South Wales School of Mines, on "Coal and its Carbonization"; by Dr. R. Lessing, on "The Study of Mineral Matter in Coal"; and others.

Crocodile River Iron Deposits. By Dr. P. A. WAGNER. Memoir 17 published by the Geological Survey of South Africa. This gives information relating to iron ore deposits in the north-west part of the Transvaal, some particulars of which appeared in the MAGAZINE for April, 1920.

Mica; Aluminium and Bauxite. Covering the war period, 1913 to 1919. Published by the Imperial Mineral Resources Bureau. Price 9d. each.

The Port of Swansea. By H. N. APPLEBY. Pamphlet published by the Swansea Harbour Trust, Ltd. This pamphlet describes the Swansea industries and the facilities for shipping. Both the text and the advertisements are of great interest to all connected with mining and metallurgy.

List of Mines in the United Kingdom, 1920. Prepared by the Inspectors of Mines and published by the Home Office. Price 10s. net. This official publication gives the names of all the mines in the United Kingdom, their owners, the addresses, nature of mineral won, and number of men employed.

Map of the Mineral Resources of the British Empire. Prepared by the Imperial Institute, and published by George Philip & Son, Ltd. Price 5s. 6d. net.

McGill and its Story, 1821 to 1921. By CYRUS MACMILLAN. Cloth, octavo, 310 pages, illustrated. Price 21s. net. London: John Lane.

COMPANY REPORTS

Mount Lyell Mining and Railway.—This company is one of the few copper producers in Australia that have been able to keep going since the heavy fall in copper, a position which has been made possible chiefly by the extensive introduction of mechanical contrivances and improved methods of treatment. Some information on this subject was given in our issue of September last. The position has also been improved by working ore of rather higher grade. The report now to hand covers the year ended September 30. During this period 196,429 tons of ore was raised, of which 91,421 tons, averaging 0·4% copper, 0·91 oz. silver per ton, and 0·8 dwt. gold per ton, came from the Mount Lyell mine; 98,556 tons, averaging 6·66% copper, 1·24 oz. silver, and 0·48 dwt. gold, from the North

Lyell mine; and 6,452 tons, averaging 3·27% copper, 0·34 oz. silver, and 0·62 dwt. gold, from the Lyell Comstock. The Mount Lyell ore went direct to the smelters, as also 29,653 tons, averaging 8·76% copper, 1·68 oz. silver, and 0·26 dwt. gold, of North Lyell ore. The remainder of the North Lyell ore went to the concentrators together with the ore from Lyell Comstock. The result of concentration was the production of 14,262 tons of sorted ore, averaging 9·87% copper, 2·06 oz. silver, and 0·4 dwt. gold, and 15,083 tons of jig, table, and flotation concentrates, averaging 15·9% copper, 2·21 oz silver, and 0·76 dwt. gold. At the smelter, 152,732 tons of ore and concentrate was treated for a yield of 5,786 tons of blister copper, which averaged 99·17% fine copper, 30·84 oz. silver, and 16·4 dwt. gold. Developments at North Lyell have given gratifying results, and 180,828 tons of ore was disclosed during the year. The reserves are estimated at 1,711,088 tons Mount Lyell, averaging 0·5% copper, 1·5 oz. silver, and 0·8 dwt. gold, and 1,095,981 North Lyell, averaging 6% copper, 1·33 oz. silver, and 0·1 dwt. gold. The accounts show, after allowance for development and depreciation, a net profit of £51,830, which was carried forward.

Mexico Mines of El Oro.—This company works a gold mine at El Oro, Mexico, adjoining the El Oro and Esperanza companies' mines. It was developed by the Mexico Venture Syndicate, formed in 1896, a company under the control of the proprietors of the MacArthur-Forrest cyanide patents. The present company was floated in 1904 by the Exploration Company, but control passed subsequently to the French group of shareholders. The report for the year ended June 30 last shows that 128,745 tons of ore was raised, of which 125,185 tons averaging $12·52 gold and 9·44 oz. silver per ton was sent to the mill, while 147 tons was picked out as high-grade ore averaging $733 gold and 692 oz. silver. The yield of gold in the mill was $1,426,291 and of silver 975,162 oz., and the high-grade ore shipped to the smelters yielded $105,370 gold and 109,885 oz. silver. The accounts show receipts of £455,999 from the sale of the gold, silver, and high-grade ore, and a net profit of £91,747. The dividends declared during the year absorbed £126,000, being at the rate of 60% tax paid. The balance carried forward was £160,015. The reserve is estimated at 311,430 tons, averaging $11·23 gold and 9·83 oz. silver per ton. These figures are 38,670 tons less than the previous year, but 30 cents gold and 1 oz. silver per ton higher. The chief developments of value have been in the Nolan section, where some ore of very high grade was discovered.

Ferreira Deep.—This company began producing gold just before the outbreak of the South African war, and in 1912 acquired the remaining portions of the Ferreira outcrop mine. The report for the year ended September 30 last shows that 390,442 tons of ore was mined, of which 223,228 tons came from the Main Reef Leader, 103,530 tons from the South Reef, 55,564 tons from the Main Reef, and 8,120 tons from the Pyritic Reef. After the removal of waste, 375,400 tons, averaging 6·82 dwt. per ton was sent to the stamps. The yield of gold by amalgamation was 91,250 oz., and by cyanide 32,155 oz., making a total of 123,405 oz. The gold realized £698,652, of which £179,833 accrued from the premium. The working cost was £500,131, leaving a profit of £18,688 at the par value of gold, or £198,521 with premium. The revenue per ton milled was 37s. 2d., and the cost 26s. 7d., leaving a profit of 10s. 7d. The dividends absorbed £147,000, being at the rate of 15%. About one-third of the ore milled during the year came from sources not included in the reserve and was of considerably lower grade. The reserve is estimated at 780,314 tons, averaging 7·7 dwt. per ton, of which 267,375 tons is in pillars and 168,400 tons is in packs. The only development remaining to be done is in ground recently acquired from Village Main Reef and Village Deep, but some prospecting will also be done on the Pyritic Reef.

Rambutan.—This company was formed in 1905 to work alluvial tin properties in the Kinta district of Perak, Federated Malay States, and it belongs to the Wickett-Osborne-Chappel group. The report now issued covers the year ended June 30, 1921. During this period the sluicing operations dealt with 516,000 cu. yd. of ground and produced 182 tons of tin concentrate, the yield per yard being 0·79 lb. These figures compare with 504,752 cu. yd., 212 tons, and 0·95 lb. for the previous twelve months. The revenue from the sale of the concentrate was £23,783, and the net profit was £12,952. The dividends absorbed £13,333, being at the rate of 13⅓%. The reduction of working costs, though these are already low, continues to receive the attention of the managers, especially as the depth of the workings is increasing and the alluvium is of clayey nature.

Tekka.—This company belongs to the Wickett-Osborne-Chappel group, and was formed in 1907 to work alluvial tin ground in the Kinta district of Perak, Federated Malay States. In March, 1920, the company was reconstructed for the purpose of making the nominal capital more nearly representative of the market value of the shares, and also to raise further capital for extensions. The new company has an issued capital of £360,000, in £1 shares, of which 320,000 shares were issued in exchange for 80,000 of similar denomination in the old company, and 40,000 were issued at par. The report now published covers the year ended March 31, 1921. During this period the sluicing operations resulted in the extraction of 367 tons of tin concentrate, as compared with 450 tons during the twelve months ended January 31, 1920, and 510 tons during the twelve months ended January 31, 1919. The yield per cubic yard was 1·49 lb., a fall of 0·33 lb. as compared with the previous period. The receipts from the sale of concentrate were £51,594, and the net profit was £20,501, out of which £18,723 was distributed as dividend, being at the rate of 1s. 1½d. per £1 share. The expenditure on tailing dams has been considerable lately, and will continue for some time.

Rayfield (Nigeria) Tin Fields.—This company was formed in 1912 as a reconstruction of the Rayfield Syndicate, and it works the Top and other alluvial tin properties on the Bauchi plateau, Northern Nigeria. Oliver Wethered is chairman, and John M. Iles is general manager. The report now issued covers the year 1920. During this period 462 tons of tin concentrate was extracted, as compared with 623 tons the previous year. The accounts show a working loss of £7,023; in addition £9,263 is due for income tax, and £4,491 for debenture interest. This position is due to the fall in the price of tin and the adverse labour conditions. Developments on the properties are reported to be still giving good results.

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EDITORIAL

A CONVERSAZIONE will be held at the Royal School of Mines, South Kensington, under the auspices of the Imperial College Union Society, on Friday evening, March 31, and members of the mining, metallurgical, and chemical professions will be welcome. Tickets, 3s. each, can be obtained from the honorary secretary of the I.C. Union Society.

A NEW appointment of considerable interest in London mining circles is that of Mr. J. A. Agnew to the board of the Consolidated Gold Fields of South Africa. We understand that Mr. Agnew will devote his entire attention to the business of this company, and will resign his directorates of all companies except those in which the Gold Fields is financially interested. Thus he will still retain his connexion with, among others, Burma Corporation and the Oroville group.

CARBONIC oxide poisoning continues to occupy public attention. A number of gas companies have widely advertised the proceedings of the meetings of their shareholders, in the course of which the chairmen have made *ex parte* statements with the object of disarming criticism. On the other hand, the Government has issued a regulation laying down the necessity for all household gas to possess the old characteristic pungent smell, in order that leakage may be readily detected. So far, so good; but it is necessary to fix a definite limit to the carbonic oxide content of the gas, and to fix that limit sufficiently low.

LAST month reference was made to the Decimal Association's weird suggestion that a litre should be called a "metric gallon." Another proposal since circulated is that the English pound weight should be altered to half a kilogram, and that the present avoirdupois grain, dram, and ounce should be increased in proportion. No doubt it would be convenient to make a pound equal to half a kilogram, but is it sound policy to change the value of all these weights while still retaining the odd ratios of values of the smaller units, namely, $437\frac{1}{2}$ grains to the ounce, 16 drams to the ounce, and 16 ounces to the pound? When thinking of upsetting units, the Association should offer some decimal advantages.

THE paper read by Dr. Mackintosh Bell before the Institution of Mining and Metallurgy last month on the Keeley silver mine at South Lorrain, Ontario, served two purposes. In the first place, valuable information on a promising silver-mining district was put on record; and second, an excellent example was provided of the services that geology can render to prospecting and development. Elsewhere in this issue we quote liberally from the paper, describing the geology of the district, the vein system, and the nature of the vein minerals. The deposits are similar to those at Cobalt, 16 miles away, but there are certain features of contrast. For instance, at Cobalt the silver-bearing veins occur in rocks of the Keewatin complex and the Cobalt series, and in the Nipissing diabase, though more than 90% of the production has come from one geological formation, the Cobalt conglomerate of the Cobalt series. On the other hand, in South Lorrain the silver veins are limited to the Keewatin rocks and associated lamprophyre dykes, and to the diabase, and they occur on either side of the contact of the Keewatin and diabase, though not actually at the contact. Then there is no such lode at Cobalt as the Wood's lode at South Lorrain for persistence and size, and for recurrence of ore-shoots one after another with little or no connexion. A third point of interest is that oxidation has gone deeper than at Cobalt or anywhere else in Ontario; the southern portion of Wood's vein shows intense oxidation to the present greatest depth, 420 ft. A fourth feature that gives rise to some discussion is the existence of a poor and almost barren zone between 250 ft. and 350 ft. It is possible that the re-occurrence of ore upwards near the surface may be due in part to a slight change in the inclination of the lode, or to some other structural feature, but Dr. Bell is of opinion that it is at least in part due to processes of secondary enrichment. As regards the general question of the origin of the ores, it will probably be best to postpone discussion of the problem as applied to South Lorrain until the workings are deeper, for the evidence of difference from Cobalt so far obtainable does not suggest any important variation in the arguments commonly applied to the Cobalt deposits. Congratulations are due to Dr. Bell for the success of his work at Keeley.

The Institution's New President

The president-elect of the Institution of Mining and Metallurgy, who will assume this position at the annual general meeting to be held next month, is Mr. S. J. Speak, a well-known consulting mining and metallurgical engineer, and member of the firm of Hooper, Speak & Co. Mr. Speak was born near Bradford, Yorkshire, in 1868, and studied first at the Yorkshire College, Leeds (now Leeds University), and subsequently at the Royal School of Mines, South Kensington, taking the A.R.S.M. in 1889. His first professional engagement was in the capacity of assistant to the late E. Bates Dorsey, who was acting as adviser to a London financial syndicate in connexion with acquiring deep-level ground on the Rand. This scheme did not mature, owing to the mining market being upset and demoralized by the Baring crisis. In 1891 Mr. Speak was sent to Damaraland by the late Sir Donald Currie, as assistant to Eugene Hoefer, who was a graduate of Berkeley, and took part in the examination of several copper and gold deposits, including the Otavi copper mine. This was before the discovery of the Tsumeb copper-lead deposit, and little of value had then been found in that part of Africa. For the next two years, 1892–4, we find him as lecturer on metallurgy at Sydney University, where the mining school was then being created. During this time he visited the principal mining districts in Victoria, New South Wales, Queensland, and Tasmania. In one of these visits he exposed the Mount Huxley swindle, where an alleged gold lode was found to be salted with alluvial gold. He did not continue as a teacher, but returned to the Rand as chief chemist and metallurgist for Rand Mines, Ltd., a position which he held for 2½ years. Here he designed and erected the cyanide plant for Geldenhuis Deep, and in this connexion was pioneer in the use of steel tanks in cyanide practice. In 1897–8 he was in Celebes for Dutch syndicates formed in the Indies, but his experiences here were far from pleasant. In 1899 he returned to South-West Africa and did much exploration between Otavi and the Cunene River. In the next year he was examining properties in various parts of Ashanti and the Gold Coast, and in 1901–2 he was superintendent of the principal camp of the Oriental Consolidated Gold Mining Co. in Korea. After visiting properties in the south of France in 1903, he went to British Columbia in 1904 to manage the Ymir gold mine. On his return to London next year he entered into partnership with Mr. Edward Hooper, and since then he has visited in consultative capacity many parts of the world, such as Siberia, Sumatra, Australia, South Africa, West Africa, and the Argentine. His work at the Rhodesia Broken Hill is well known, and he described it in the MAGAZINE for October, 1919. It will be seen from the above brief record that Mr. Speak's experience is of the widest. His professional life is characteristic of the best traditions of the English mining engineer.

False "Mining Engineers"

Last month we published a letter from Mr. C. McDermid, secretary of the Institution of Mining and Metallurgy and the Institution of Mining Engineers, drawing attention to the case of Joseph Aspinall, a soi-disant mining engineer, who was sentenced recently in the Central Criminal Court to twenty months' imprisonment with hard labour for misappropriating large sums of money belonging to the Crafnant and Devon Mining Syndicate, Ltd. Aspinall formed this company in 1918 ostensibly for the purpose of working lead properties near Trefriw, North Wales, and he had raised large sums privately from a variety of people who believed that they were going to make their fortunes. The company came to grief, and was wound up by order of the Court last year. The facts then disclosed showed that the money raised was spent mostly in riotous living, and that little or no mining was done.

After the trial was finished some details of Aspinall's record were given in the court. He started as wagon-boy at a Lancashire colliery, and in 1902 he established a business as manufacturer of colliery appliances. Subsequently he took a lease of a colliery in Staffordshire. He became bankrupt in 1912, and next year he was convicted of perjury in connexion with statements made by him at the bankruptcy proceedings.

In the letter published last month, Mr. McDermid officially protested against men of this type dubbing themselves "mining engineers", and calling on investors and speculators to make sure of the qualifications of anyone using such a title. Unfortunately public opinion is not yet ripe for the imposition of a legal restriction on the use of the title, and it is, indeed, doubtful whether this restriction will ever come about.

Unfortunately, also, the law is such that warnings against shady individuals who are asking for money can only be publicly uttered at considerable financial risk. However much the members of the two Institutions might desire that the operations of "mining engineers" should be nipped in the bud by official action by their councils, they would hardly agree to the hypothecation of funds for the purpose of preparing a legal defence for a libel action. In any case, such warnings in advance would seldom be seen by the victims who put up money. All that the Institutions can do in this matter is to indicate the easiest way of determining a "mining engineer's" qualifications, that is to say, to inquire if the gentleman in question is a member, or if the Institutions know him.

Mr. McDermid also appeals to the Press in general to help the profession and also the investor by pointing out the necessity for discriminating between mining engineers and "mining engineers." The Press generally has the same fear of the law of libel as the Institutions have, and, what is worse, most of the popular papers believe the statements in the prospectuses they advertise. The financial papers of standing do not care for lawsuits, but their editorial staffs continually give sound advice and warnings to private inquirers through the column "Answers to Correspondents." On the other hand, there are a great many papers dealing with financial matters which, to the ignorant, look like straightforward financial papers, but which give "interested advice," so that often it takes as much skill to differentiate between good and bad newspapers as between good and bad financial schemes.

There is only one paper that makes a specialty of genuine and candid public criticism of undesirable features of finance and of taking a vigorous offensive against frauds. We refer to *Truth*, whose editor, Mr. R. A. Bennett, and financial editor, Mr. T. Colsey, together with their many special advisers, are quite outspoken in their advice and criticism, and are uninfluenced by fear of the law of libel or by offers of revenue to be derived from the advertising of particular shares. This paper was early in the field with a warning respecting the Crafnant and Devon affair, and had this received the attention of those financing the concern much money might have been saved. One of *Truth's* typical exposures was in connexion with the failure of the Charing Cross Bank. Attention was drawn in its pages to the fraudulent incorrectness of this so-called bank's balance-sheets three years before the inevitable crash arrived, and it was through the paper's instrumentality that an inspection of the bank's books was ordered by the court. In mining matters one of its excellent services was to give warning against the boosting of the Northern Exploration Company's shares. *Truth* is not scared by the receipt of a writ, and refuses to refrain from criticism after receipt. It is usually supposed that a newspaper commits contempt of court by continuing its remarks after the issue of a writ, because the matter then becomes *sub judice*. Probably 99% of the libel writs issued have no other purpose than the stoppage of criticism. To be effective criticism must be continuous and oft-repeated. Of course, risk is run by following this policy, and for that reason, if for no other, a paper willing to assume this risk as well as others should be supported by all investors, intelligent and otherwise. We have drawn attention to the function performed by *Truth* in financial journalism in order that mining engineers shall know that there is at least one paper that is ready to give due prominence to all genuine grievances.

The Minerals of Yugo-Slavia

In this issue we publish an informative and timely article on the iron-ore resources of Yugo-Slavia, written by Mr. D. A. Wray, a member of the Geological Survey of Great Britain, who was attached to the British Economic Mission to Serbia. Mr. Wray made a very thorough examination of the geology and mineral resources of this new European State in the years 1920 and 1921. His general report was printed for private circulation last year, and has only recently been made a public document, being now obtainable at the Stationery Office at the price of 3s. 6d. It is a most comprehensive and detailed report, and it makes available for the first time to the English reader a full account of the mineral resources of that part of Europe. Hitherto this information has been found only in Serbian, Austrian, and German records, not all of which were easily accessible even to residents in those countries.

Yugo-Slavia is a State in which are reunited a number of smaller states that had been kept apart by Austrian and Balkan intrigue, Serbia proper being the only one of the states that maintained a nominal independence. From the mineral point of view perhaps the most interesting result of this political rearrangement is that the celebrated quicksilver mines of Idria and the lead mines of Bleiberg are now in Slovenia, the most westerly state of Yugo-Slavia, instead of in the old Austrian state of Carniola. From the point of view of practical mining, the most important result of the combination of these smaller states will be the provision of better means of communication and the consequent possibility of developing deposits that have hitherto lacked commercial attractiveness. The history of mining in these States is a complicated one. Operations in many places date back from the time of the Romans, and the various revivals of activity appear largely to have been prompted by military requirements. During the Great War the Austrians and Germans drew liberally on the iron, manganese, copper, and other resources. Since the Armistice mining has been under a cloud there as in many other parts of the world, but opportunities now offer for the use of outside capital.

In looking through Mr. Wray's report, it appears that the iron deposits are perhaps of greater immediate commercial importance than any other. The article which we publish gives a full account of these deposits and their possibilities, so nothing further need be said here. The coal deposits are widely spread throughout the various states, but as they are mostly of the nature of brown coal and lignite, their applications are confined within well-known limits. The metallic minerals, other than those already mentioned, which have been worked or investigated are numerous and are distributed fairly widely, and, as we have said, the increasing facilities for communication should help to revive decayed industries and encourage the floating of new ventures. Copper, lead, zinc, silver, antimony, gold, and pyrites have all been worked extensively in the past, and are likely to receive increased attention in the future.

Gold, both lode and placer, was worked in Serbia and Bosnia by the Romans, and also in the Middle Ages. There are many lode-gold mines in eastern and north-eastern Serbia, in the high mountain regions which form the continuation of the Transylvanian Alps, while in the valleys of the Pek and the Timok, and their tributaries, there are valuable placers. Just before the Great War four dredges, two English and two Belgian, were operating on the Pek River, near Neresnika, and lode-gold mines were being worked at Deli-Jovan and Blagojef Kamen. Since the war a Serbian company has re-started dredging the Pek gravels. As regards the quicksilver, the Idria mines have yielded 400 to 700 tons yearly for a great length of time, and during the war the extraction was intensively conducted with a view of obtaining as much material as possible for the manufacture of fulminate. Cinnabar is also found in Serbia, where deposits at Ripanji were worked before the war by an English company. Copper has been an important product in Serbia for many years, and the mines at Majdanpek and Bor in the north-eastern mountains are well known. In fact, Majdanpek is one of the most important mining centres in eastern Europe, and has been the seat of mining for copper, iron, and gold from time immemorial. During the war, when Serbia was under Bulgarian military control, large amounts of copper and iron ores were sent to Austria for smelting. In Bosnia copper has been produced at Maskara, where cinnabar is also found. Copper has also been mined in Croatia and Serbian Macedonia. Lead and zinc ores are found in Slovenia, Bosnia, and Serbia, and they have been extensively worked. Those in Slovenia are chiefly at Bleiberg, which, as already mentioned, used to be in Austria, and which produced about 45,000 tons of lead per year. In the same district are the Littai lead mines, and the Cilli zinc mines and smelters. In Bosnia the Srebrenitsa mines have yielded lead for many centuries, and in Serbia the Avala, Kosmaj, Rudnik, Podgorina, Kucajna, and Krupanj groups of mines are of considerable importance. Of other metallic minerals that have formed the basis of mining operations, stibnite and chromite deserve mention. The former has been worked at many centres, the most important of which are in north-eastern Serbia, while the latter has been worked at Dubostitsa in Bosnia.

The foregoing is, of course, a mere outline of the resources of Yugo-Slavia and of Mr. Wray's report, but it will be sufficient to revive interest in a country of mineral possibilities. The Government is to be thanked for making the report public property, for information of this nature cannot be too widely circulated in commercial quarters.

REVIEW OF MINING

Introductory.—The metal market continues very depressed and prices are still at a low level, the movements being up and down alternately in a manner disconcerting to those who hope for a permanent improvement. The engineering industries of this country are threatened with another strike, arising out of a dispute respecting regulations as to over-time. The only department of trade where an increase of business is noticeable is that devoted to the export of coal. It appears that many countries over sea that were obliged to try American coal owing to war conditions and strikes are now coming back to the use of English and Welsh coal.

Transvaal.—A second month has gone by without any progress having been made towards a settlement of the labour question. The daily cables are as difficult to interpret as ever. There is no doubt, however, that the Chamber of Mines is standing firm. The men's position is not clear, for first we hear that they want to go back on the Chamber's terms, and then that the whole of labour throughout the Union is to be called out ; also that the unruly element gets occasionally out of hand. At the time of writing the violence is serious, and Government troops are requisitioned.

Reports on the ore reserves at Geduld and Modder Deep, the two principal mines controlled by the Union Corporation, afford excellent reading. At the Geduld, the reserve is estimated at 3,545,000 tons, averaging 8·1 dwt. per ton, as compared with 3,220,000 tons, averaging 8 dwt., the year before. This is sufficient to keep the mill going for 6½ years, and it is probable that when times are more settled the company will increase its scale of operations. At Modder Deep, the reserve is calculated at 4,375,000 tons, averaging 9·3 dwt., as compared with 4,100,000 tons, averaging 9·4 dwt. As this is one of the smaller properties of the Far East Rand, any expansion of rate of output would not be warranted.

The Crowe vacuum process, which is now part of the Merrill precipitation system, is being introduced on the Rand, and good results have been obtained. The Merrill and Crowe system is to be adopted in the New State Areas mill.

Cape Province.—Reference was made last month to the strange prospectus of the Orange River Asbestos Mines, Ltd. Since then a number of firms connected with the asbestos trade who were mentioned in the prospectus [illegible] publicly denied any knowledge of the company's affairs, while Mr. J. J. Davies, an engineer whose report was quoted, has obtained an injunction against its further use until his action can be heard. Mr. Davies says his report was made several years ago, when trade was in a very different position from what it is now, and he protests against the date being left out when his report is quoted or its being used in any way at present.

Tanganyika.—The Mining Regulations which came into force at the beginning of the year in Tanganyika Territory (late German East Africa) have been published. These regulations deal with the safe working of mines and cover the use of machinery, explosives, blasting, protection of the surface, underground operations, winding, ventilation, and lighting. Copies can be obtained from the Department of Overseas Trade, 35, Old Queen Street, Westminster.

Congo State.—Active progress is being made with the leaching scheme and with the concentration plant at the Union Minière copper mines. At the smelters powdered coal is to be employed as already announced. The necessary plant is on the spot, and Mr. U. A. Garred has arrived from New York to supervise its installation.

Rhodesia.—The output of gold for January is reported at 53,541 oz., as compared with 55,968 oz. in December, and 46,956 oz. in January, 1921. The outputs of other metals and minerals for January were : Silver, 13,696 oz. ; coal, 49,830 tons ; chrome ore, 1,494 tons ; copper, 286 tons ; asbestos, 558 tons ; arsenic, 41 tons ; mica, 4 tons ; diamonds, 4 carats.

West Africa.—The Ashanti Goldfields Corporation has issued a report on development during the quarter ended December 31 last. The particulars relating to the Obuasi shoot on the 19th level, the present deepest, confirm the cheerful view expressed on the first intersection of the lode as recorded in our issue of August. At that point the lode was 26 ft. wide and averaged 19·9 dwt. gold per ton. Subsequent test cross-cuts gave the following results : 26·7 ft., averaging 18·1 dwt. ; 23 ft., averaging 20·1 dwt. ; 30·7 ft., averaging 27·4 dwt. ; 29 ft., averaging 33·8 dwt. ; and 24 ft., averaging 20·7 dwt.

Nigeria.—The Bullfinch directors state that their engineer reports unfavourably as to the Jebba gold option ; he has been instructed to continue prospecting in other areas. No official news from Mr. James Shea, who went to Nigeria for the Great

Boulder, has been so far published; unofficially it is stated he is at Birnim Gwari, examining the gold areas of the Naraguta Company.

Directors of mining companies have protested on many occasions lately against the high taxes and costs in connexion with operations in Nigeria. Last month these grievances were forcibly accentuated at the meeting of the Niger Company by the Hon. W. Hulme Lever, who presided. He gave many specific cases of the way in which the cost of the products of the country were increased by taxes, railway rates, and shipping charges, and also how the same influences made the selling prices of imported articles outrageously high. He pointed out that in this way the native producer was hit in both directions and, in consequence, was greatly discouraged as a trader. Since Mr. Lever uttered this protest, some steps have been taken by shipping companies to ease the situation, and a similar step on the part of the Government is confidently expected.

Australia.—The mining and labour position continues uncertain. While on the one hand the Moonta copper mines are closing owing to the low price of copper and the refusal of the Unions to sanction an adequate cut in wages, the Mount Morgan directors report that the strike has come to an end and that work will be resumed early this month. At Mount Lyell it has been decided not to smelt any of the Mount Lyell ore itself but to depend entirely on North Lyell ore. Mount Lyell ore is of low grade in copper and gold, but its pyritic content makes an ideal smelting mixture with the richer but siliceous North Lyell ore. The plan now is to extend the concentration plant at North Lyell and make a product suitable for smelting without use of the Mount Lyell ore. A sum of £20,000 is being spent in extending the concentrators to a capacity of 12,000 tons of ore monthly. At the Broken Hill steel works, Newcastle, conditions are very unfavourable on account of high costs, and it is almost impossible to obtain orders against European competition. Consequently it has been decided to suspend iron and steel production after the present orders are filled until such time as labour can be reorganized on a lower level of wages and higher efficiency.

A further distribution, amounting to 1s. 6d. in the pound, is to be made to debenture-holders in Great Cobar, Ltd., bringing the total distribution to 6s. 6d. The outstanding debentures amount to £667,300, and the holders have received in all £216,872. Seeing that the quotation for the debentures a year or more ago was from 7 to 11%, it is clear that much more has been realized by the sale of property and plant than was expected. This satisfactory result is due to the shrewdness of Mr. W. Pellew-Harvey, who has had the matter in hand, acting for Sir Arthur Whinney, the receiver and manager. There is still some property to be sold, so that in all probability another, but smaller, distribution may be made.

Eighteen months ago the Badak collapse created much sensation in Melbourne. It will be remembered that this Malayan tin property was reputed to be very rich, and the shares of the company were pushed to absurdly high prices. When work was commenced, the promoter's figures were not confirmed. In fact, the ground was shown to be poor. In December, 1921, the so-called discoverer and two directors of the company were charged with conspiring to defraud. They have now been committed for trial. It is hoped that full details of the transactions will be made public.

India.—The refinery of the Attock Oil Company at Rawal Pindi was opened on February 11 by the Governor of the Punjab. This refinery has a daily capacity of 65,000 gallons of crude oil. The oilfield developed by the company is at Khaur, 42 miles to the south-west. There are 23 wells at present yielding, varying in depth from 250 ft. to 2,400 ft., and others are in course of sinking.

South Wales.—The zinc-smelting works are now all re-starting or on the point of doing so. The first to start was the Swansea Vale works, which reopened two months or so ago, as recorded at the time. The main material to be treated will in most cases be the Australian concentrates. We do not hear that the various works are to pool their experience on this material; this seems a pity, for they will have much to do to keep pace with Belgian technical skill.

Cornwall.—The Levant Tin Mines, Ltd., announces that the operations foreshadowed in our November issue were commenced on February 13. This plan was inaugurated by Colonel Freethy Oats, and comprised the erection of some modern stamps purchased from Tincroft. These stamps are now crushing material accumulated under the old mill. It is hoped that sufficient tin will thereby be recovered to pay for keeping the mine in working order until such time as general conditions improve. The accounts for the two years 1920 and 1921 will be circulated about the end of this month.

At the meeting of shareholders in Dolcoath Mine, Ltd., held last month, Mr. R. Arthur Thomas discussed the company's application under the Trade Facilities Act of 1921 for the guarantee of a capital sum sufficient to carry out a modified scheme of development of the northern areas. It is hoped that fresh funds will thereby be forthcoming for re-starting work. It will be remembered that about two years ago it was proposed to develop this ground by means of a long cross-cut northward from the Williams shaft at the 338 fathom level. This plan has been abandoned, as the water has risen above the level in question. It is now proposed to sink a new shaft between the North and South Roskears, simultaneously unwatering the old South Roskear mine. In many quarters this new plan is considered more economically sound than the original one. Full details, with illustrations, of these schemes were given in our issue of January, 1921.

Various items of news have been circulated recently with regard to the reopening of uranium-radium mines in the historic district of the upper Fal, but the information given is vague. In one case the only "authority" quoted as to the value of the deposits is Mr. Silas K. Hocking, the novelist, whose right to speak on the subject appears to be that he was born somewhere in this valley.

Canada.—The steady progress of the Hollinger, Dome, and McIntyre mines continues to attract attention to Porcupine as a gold producer. The expansion of the scale of operations at Hollinger to bring the daily output of ore to 7,000 tons is an important event in the history of mining, for it brings the mine to the level of Crown Mines on the Rand. Technical details have not been published recently by the board, and there is nothing available on which to judge the position since Dr. Mackintosh Bell wrote of the subject in our issue of September, 1920.

The Mining Corporation of Canada is about to start systematic development of the Haileybury-Frontier silver property at South Lorrain, and has transferred thither some of the plant at the Cobalt Lake property. This property is to the north of the Keeley mine, which is developing so well.

United States.—The annual meeting of shareholders in the Arizona Copper Company, which was held in Edinburgh on February 27, was not of great importance from the financial point of view, as there was nothing to add to the information given at the meeting a few months ago, when it was agreed to sell the properties to the Phelps Dodge Corporation. Opportunity, however, was afforded for the board and shareholders to express their continued confidence in Mr. Norman Carmichael, who had for twelve years or more been general manager at the mines, and it was decided to fall in with the Phelps Dodge directors' desire that he should be appointed a director of the Corporation.

Mexico.—The Exploration Company, whose chief interests are nowadays in Mexico, presents a very contracted report for the year 1921, and does not recommend a dividend. The particular cause of this adverse position is stated to arise from the Buena Tierra company, a subsidiary floated in 1912 to work a silver-lead mine in Chihuahua. This mine has never yielded a profit, and was shut down last June owing to the low grade of the ore mined, the high cost of production, and the poor results of development.

France.—Drilling at the Villemagne lead-zinc-silver property in the south of France is being actively conducted by the Russo-Asiatic Consolidated. The latest report states that No. 19 bore-hole passed through two beds before meeting the main lode. At a depth of 207 ft. to 212 ft. the first bed was cut, averaging 11·8% lead, 1·9% zinc, and 4·4 oz. silver per ton; the second bed at 246 ft. to 260 ft. averaged 19·2% lead, 5·6% zinc, and 6 oz. silver; while the main lode below was found to be 19 ft. wide, averaging 7·7% lead, 16·3% zinc, and 3·9 oz. silver per ton. No. 20 bore-hole cut the lode at 258 ft., where it was 36½ ft. wide, averaging 8·3% lead, 8·4% zinc, and 3·4 oz. silver. Bore-hole No. 21 is the deepest yet sunk; it encountered a bed 47 ft. wide at 583 ft., averaging 6·6% lead and 2·1 oz. silver, and the lode at 672 ft., 18 ft. wide, the recovered part of the core averaging 13·2% lead, 4·1% zinc, and 4·4 oz. silver.

Persia.—The unfortunate position created by the granting of certain oil concessions to the Standard Oil Company in connexion with which Anglo-Persian already had a grant has been remedied by the two companies agreeing to work the territory conjointly. In all probability a company will be formed in which the capital will be subscribed in equal amounts by the two parties.

THE ROASTING OF ZINC-BLENDE ORES

By GILBERT RIGG and W. J. McBRIDE

The Authors, who are metallurgists with the Broken Hill Associated Smelters and the Electrolytic Zinc Co. of Australia, and the Broken Hill South, respectively, examine the process of roasting zinc ores with the object of securing the best result at the lowest cost.

INTRODUCTION.—The object of the present paper is to set out in some detail certain factors which the development of the roasting process in Australia has shown to be of importance, and to illustrate them as far as possible by reference to actual practice. The high cost of fuel and labour has rendered a radical departure from pre-war practice essential, and the aim has been to make the utmost possible use of the potential heat residing in the ore itself, and at the same time to substitute mechanical appliances for hand labour.

The work referred to here has been carried out for the most part on Broken Hill zinc concentrates, and the results achieved to date may be summed up as follows: The fuel consumed in roasting down from 30% sulphur to 1% sulphur amounts to 0·75% of coke breeze per ton of ore roasted; the labour consumed in the same operation amounts to one man for five tons of ore roasted; the roasted product is superior to that obtained by pre-war methods of roasting when used in the zinc retorts.

As indicated in a previous paper (see THE MINING MAGAZINE, June, 1918, page 285), the method of attack followed has been to roast in two stages, the more easily attackable sulphur being roasted off in the first stage and the residual more difficult sulphur in the second stage. Both stages have been carried further since the original paper was written, more especially the first roast, the object being to take full advantage of the remarkable efficiency of the blast-roaster (Dwight-Lloyd machine) for the second stage by developing as far as possible the first stage. As regards the final product, namely, the roasted and sintered ore, the claims made for it as to its pre-eminent suitability for the distillation retort in the earlier paper have been amply substantiated by later developments.

We shall now proceed to the discussion of the principal factors underlying the economical roasting of zinc blende. These may be set down as follows:—

(1) The maintenance of contact between the oxygen of the atmosphere and the ore particles.

(2) The regulation of the temperature.

(3) The size of the ore particles.

These three factors are so closely connected that to discuss one without some reference to the other two is not possible. Nevertheless, the classification is a useful one, and discussion under these three heads will help to bring out the salient characters of each. In each case the discussion will have reference to two types of roasting, namely: (*a*) Roasting on a hearth; (*b*) roasting on a blast-grate. The former has been used as a pre-roasting furnace, the latter as a finishing roaster.

(1) THE MAINTENANCE OF CONTACT BETWEEN THE OXYGEN OF THE ATMOSPHERE AND THE ORE PARTICLES.

(*a*) *Roasting on a Hearth.*—In the case of Broken Hill concentrates the charge is composed of a mixture of sizes, all of which will pass through a 30 mesh I.M.M. standard screen. These sizes are distributed approximately as follows:—

	%
On 60 mesh	25
Through 60 on 160 mesh	50
Through 160 mesh	25

Comparing the weight in lb. per cubic foot of the concentrates with the weight in lb. per cubic foot of solid zinc-blende we find that the volume of the blende particles and the volume of the voids are substantially equal.

Now it is a matter of experience that in such a close-textured mass of particles as are present here, the rate of diffusion of a heavy gas like SO_2 is very slow. It is of interest, therefore, to inquire how long it will take for the air in the interstices of the charge to be completely converted into SO_2 and N. Calculation shows that the composition of this mixture of gases will be 13·7% SO_2 and 86·3% N.

In the case of an eight-hearth furnace 20 ft. in diameter, we have a total load of ore in the furnace of 45 tons. The furnace roasts 70 tons ore per 24 hours from 30% down to 9% sulphur, or in round figures 15 tons sulphur are oxidized and eliminated as SO_2. The reason for choosing 9% sulphur as the pre-roasting limit will be explained later. Hence the average time required to convert 1 lb. sulphur into SO_2 is

$$\frac{1,140}{15} \times \frac{60}{2,240} = 2\cdot6 \text{ seconds.}$$

The solid zinc-blende has a volume of 9 cu. ft. per ton. Hence, the total volume of blende in the furnace is $45 \times 9 = 405$ cu. ft., which is equal to the volume of interstitial voids. 405 cu. ft. of gas at 13·7% SO_2 = 55·5 cu. ft. SO_2, which at S.T.P. weighs $55\cdot5 \times 0\cdot17862 =$ 9·9 lb. SO_2. At 870° C., the mean temperature of the roasting ore, the weight becomes

$$9\cdot9 \times \frac{273}{1,143} = 2\cdot4 \text{ lb. } SO_2 \text{ or } 1\cdot2 \text{ lb. sulphur.}$$

As already shown the time required to convert 1 lb. sulphur into SO_2 is 2·6 seconds. Hence the time required to fill up the interstices of the ore with SO_2 and N, and bring interstitial roasting to a stop is $2\cdot6 \times 1\cdot2 =$ 3·12 seconds.

Rabbling the ore at the rate of one revolution in 3 minutes with two arms per hearth, the ore is rabbled once every 90 seconds. Hence assuming that diffusion is negligible, interstitial roasting takes place during only 3·5% of the time. This figure is, if anything, too high. In the first place, on all the hearths there is more or less SO_2 in the furnace atmosphere, so that the supply of oxygen in the interstitial atmosphere is thereby reduced. In the second place, it is unlikely that the whole of the interstitial gas is driven out of the ore when the rake passes, as the disturbance is not very severe. And lastly, the contact between interstitial gas and ore is so good that the exhaustion of the oxygen would be almost instantaneous. Against this we have the fact that diffusion of oxygen inwards and SO_2 outwards does occur to some extent; however, as will be shown later, this amounts to a small figure only. For the present it may be pointed out that the rate of roasting when interstitial roasting actually does take place, as on the D. & L. machine, is so large as compared with hearth-roasting, that the extent to which diffusion of oxygen can take place into the charge on the hearth must be very small indeed.

Next consider the amount of ore which is roasted between rabblings on the 20 ft. diameter furnace. This interval amounts to 1·5 minutes. Then at 70 tons ore roasted per 24 hours we have roasted in 1·5 minutes:

$$\frac{70 \times 2,240 \times 1\cdot5}{1,440} = 163 \text{ lb.}$$

equal to approximately 1·16 cu. ft. of ore as it lies on the hearth. Dividing this by the total hearth area of the furnace, namely 2,400 sq. ft., the quotient is $\frac{1}{200}$ in., which is approximately the thickness of a layer of ore equal to the amount roasted between rabblings. Hence, having regard to the much greater opportunity that the surface particles have to get roasted than the interior ones, it is obvious that this small amount must be mainly roasted at the surface. Hearth-roasting, then, is to be regarded as occurring only at, or very close to, the surface of the charge.

As the roasting proceeds the proportion of unroasted particles diminishes and consequently the number of such available at the surface after each rabbling diminishes in proportion. Under these circumstances a falling off in the rate of roasting as the ore passes from hearth to hearth is to be expected. This is entirely borne out in practice.

Under these circumstances it is obvious that the more opportunity we can give for the oxygen of the air to come into contact with the sulphide particles while the latter are at the surface, the more rapid will be the roasting, up to a stage at which all the surface particles are completely oxidized before the ore is turned over by the rabbles and a new surface exposed.

The volume of air necessary to roast one volume of blende without any excess oxygen, the resulting gas being 13·7% SO_2 and 86·3% N, would be at S.T.P. as follows:—

1 lb. blende at 29% sulphur available yields 0·58 lb. $SO_2 = \frac{0\cdot58}{0\cdot1786} = 3\cdot247$ cu. ft. SO_2.

$$\frac{3\cdot247 \times 100}{13\cdot7} = 23\cdot7 \text{ cu. ft. gases at S.T.P.}$$

$$\frac{23\cdot7 \times 1,143}{273} = 99\cdot2 \text{ cu. ft. at } 870^\circ \text{ C.}$$

Volume of air corresponding =

$$\frac{86\cdot3 \times 99\cdot2 \times 100}{100 \times 79} = 108\cdot4 \text{ cu. ft. air.}$$

Volume 1 lb. blende

$$\frac{1}{62\cdot5 \times 4\cdot1} = \frac{1}{256\cdot25} \text{ cu. ft.}$$

Hence volume of air corresponding to one volume blende =

$$108\cdot4 \times 256\cdot25 = 27,750 \text{ volumes.}$$

Every particle of blende must therefore come in contact with 27,750 times its own volume of air before it is dead-roasted, or 20,000 times its own volume to produce a roasted ore carrying 9% sulphur. Obviously this will require time, and time in proportion as the circulation of the air in contact with the ore is good or bad. Considering, however, the different types of hearth-roasters in use, there seems to us to be plenty of room for further improvement here, more especially when we take into account the tendency that the heavy SO_2 gas has to cling to the upper surface of the charge. This is a drawback to multiple-hearth furnaces, where the space necessary to accommodate the rabbling arms makes a considerable height between hearth and hearth essential.

In these furnaces the gas passes through the peripheral drop-holes at a linear velocity of approximately 40 ft. per second and strikes the underside of the hearth above. Its tendency is then to flow in contact with the arch above rather than the ore below. The ore as it roasts enriches the stratum of air in contact with it with SO_2, and so tends to stop the roasting, SO_2 being a heavy gas and slow to diffuse.

In a furnace 20 ft. in diameter, and with arches 1 ft. 6 in. above the surface of ore at the periphery and 2 ft. 3 in. at the middle, with a 6 ft. 6 in. annulus at the centre, roasting 70 tons daily at 9% sulphur, the mean linear radial velocity of the gases is about 3½ ft. per second 6 inches from the periphery, and 6½ ft. per second 3 ft. from centre, the gas taking about 15 seconds to pass through the furnace. Such velocities are very low and insufficient to keep the surface of the ore swept clear of SO_2 enriched gas. Furthermore, the ore near the periphery and lying between adjacent drop-holes, has a poor chance of getting properly ventilated, stagnation being the rule at these points, and as the area of the annulus near the periphery is large, it means inefficient work over a considerable section of the hearth.

On the other hand, the fact that we are only roasting down to 9% sulphur offsets to a considerable extent the defects of hearth roasters in their present state of development. Comparing, for example, our present practice on a multiple-hearth circular roaster with good standard practice on a Mathiessen and Hegeler furnace, we arrive at the following figures. On the standard Mathiessen and Hegeler furnace 40 tons are roasted per 24 hours from 30% sulphur down to 1%. This corresponds to 4·5 lb. sulphur roasted off per sq. ft. of hearth per 24 hours. On a circular furnace 20 ft. in diameter and 8 hearths high, 70 tons are roasted to 9% sulphur, or 14 lb. sulphur roasted off per sq. ft. of hearth per day. We have not had the opportunity of trying out what an M. & H. furnace would do roasting down to 9% only, but judging from the results obtained on Ropp furnaces we should expect to get about 9 lb. sulphur roasted off per sq. ft. of hearth per day, with less than half the consumption of coal per ton of ore roasted.

Returning now to the question of improving the contact between air and ore, we have certain possibilities to consider. It has been proposed to recirculate part of the roaster gases by drawing them from the upper hearths and returning them to the lower hearths, thus bringing the high temperature gases from above into contact with the ore on the lower hearths, which are at a lower temperature owing to diminishing sulphur content and at the same time speed up the velocity of the gas in the furnace. This scheme, however, has various drawbacks in practice. The high temperature of the gases is severe on the circulating fan, and the drop-hole area does not admit of maintaining a large volume of extra gas in circulation without creating a certain amount of back pressure, which causes the gas to leak out through the doors in a manner that is rather trying to the attendant. Again, we do not get over the difficulty caused by the vertical path taken by the gas passing through the drop-holes, which tends to prevent it from sweeping the surface of the ore as it should, nor does it get away from the difficulty that the area lying between the drop-holes is not directly affected by the circulation. Finally, having regard to the considerable height between hearth and hearth, even if the volume of the gases were doubled, the velocity would not be very high.

In our work on this subject we have aimed to make use of a much smaller quantity of air sent through a nozzle at high velocity, the object being to induce circulation in the horizontal direction rather than in the vertical, and at the same time to avoid the use of large additions to the volume of gases traversing the drop-holes. This notion has been combined with the introduction of fine concentrates by means of the transporting power of this secondary air, the object being to maintain the temperature of the lower hearths against the introduction of this cold air, and against the low sulphur content of the ore on the lower hearths.

The volume of air is much smaller than would be required to roast the fine concentrates introduced at the nozzle. This latter settles on the surface of the ore on the hearth and ignites there. The effect of the disturbing action of the air from the nozzle on the furnace atmosphere together with this addition of fuel where it is most needed, is very marked, but the analysis of the fine concentrates screened out of the ore taken from the hearths into which the nozzles are directed shows that roasting does not take place while the ore is in a state of suspension. This point will be more fully explained when dealing with the question of the effect of the size of the ore particles.

We have already pointed out that the smaller the proportion of unroasted particles remaining in the charge the less opportunity there is for the maintenance of sufficient sulphide particles at the surface to keep up vigorous roasting. The addition of the fine concentrates by means of the nozzles is, therefore more effective when applied to the lower hearths than to the upper where plenty of unroasted material is available to keep up the temperature.

It has been a matter of considerable surprise to us that changes in the shape and size of rabbles make but little effect on the roasting rate. This we regard as additional confirmation of the lack of proper circulation of the furnace atmosphere. In other words, the amount of surface exposed by each rabbling is well in excess of that which can be properly supplied with oxygen.

(*b*) *Roasting on a Blast-Grate.*—Roasting by causing the air to pass in between the particles of ore might in the light of what has been said under heading (*a*) be expected to show a considerable increase in the rate of operation. The increase, however, is extraordinarily large. If, for example, we had a blast-grate with an area of 2,400 sq. ft., instead of burning 15 tons of sulphur per day we should burn 260 tons. This furnishes the most striking proof of the importance of contact between the atmospheric air and the ore particles.

Following out the discussion in the foregoing section as relating to the rate of renewal of the interstitial gas, we find a very different set of conditions in the blast-roaster from that which occurs on a hearth. In the blast-roaster the air passes through the bed of ore instead of over it, and consequently roasting proceeds right through the mass. As the volume of voids is substantially equal to the volume of the ore, and the volume of air required based on a gas containing 5% SO_2 is 32,000 times the volume of the ore, the passage of the air through the ore-bed is exceedingly rapid, and the chances of stagnation very remote. The rate of passage of the air through the bed can be readily calculated as follows.

As explained in the previous section, the ore is roasted down to 9% sulphur before going to the blast-grate. The SO_2 content of the gas is 5%. Hence the volume per ton of ore at 900° C. equals 162,000 cu. ft. The charge on the grate is 4·5 in. thick, so that per square foot we have $\frac{4 \cdot 5}{12} = 0 \cdot 375$ cu. ft. The volume of voids is half this, or 0·1875 cu. ft. Hence the gas per square foot corresponding to the roasting of the charge to 1% is :—

$$0 \cdot 1875 \times 62 \cdot 5 \times 4 \cdot 1 \times \frac{162{,}000}{2{,}240} = 3{,}480 \text{ cu. ft.}$$

Hence the interstitial gas is renewed $\frac{3{,}480}{0 \cdot 1875} = 18{,}600$ times during the roast.

The roasting operation occupies 14 minutes. The renewals take place therefore $\frac{18{,}600}{14 \times 60} = 22$ times per second.

The mean linear velocity of the air passing through the charge is given by $\frac{3{,}480}{0 \cdot 5} =$ 6,960 ft. in 14 minutes, or 498 ft. per minute = 8·3 ft. per second.

The time of contact between air and ore is

$$\frac{4 \cdot 5}{12} \times \frac{1}{8 \cdot 3} = 0 \cdot 045 \text{ seconds.}$$

One more figure will help to illustrate the rate at which roasting proceeds under these circumstances. Supposing the grains of ore were all $\frac{1}{100}$ in. in diameter (as a matter of fact, they range from $\frac{1}{60}$ in. down to $\frac{1}{400}$ or less), and a column of grains 4·5 in. thick takes 14 minutes to roast, hence, as roasting proceeds from top to bottom in succession, the mean time to roast one grain is $\frac{14 \times 60}{450} = 1 \cdot 87$ seconds.

It might well be asked why, under these circumstances, the ore should not be roasted directly on the blast-grate, instead of being first pre-roasted on a hearth to 9% sulphur. The answer to this question will be found in the discussion on temperature regulation further on.

2. The Regulation of the Temperature.

(*a*) *Roasting on a Hearth.*—The temperature limits between which roasting of ordinary Broken Hill concentrates can be carried on to the best advantage are rather narrow, lying between 860° and 900° C.; the nearer the ore can be kept to a mean temperature of 880° the better. Above 900° the strain upon a mechanical furnace becomes severe, although the system of air-cooling the column and arms in the Skinner furnace has shown up very well. Further, lead is driven off in large quantities and there is danger of sintering the ore. Below 860° C. the roasting rate begins to fall off seriously, and there is danger of the formation of sulphate of zinc. Below 800° C. this becomes a great nuisance.

In an 8-hearth furnace the second hearth is naturally hottest, the top hearth serving mainly to ignite the ore, and the second receiving it ready ignited, but with its sulphur content practically undiminished. The third is also a vigorous hearth, and after that the hearths become successively cooler and less effective unless their temperature be reinforced in some way. This temperature fall becomes more and more marked as the sulphur content aimed at in the final roast becomes less and less. If a dead roast is aimed at, coal or some other fuel must be used to maintain the temperature at the end. If 9% of sulphur is to be left in the roasted ore, no fuel is necessary, the temperature being maintained sufficiently high by the sulphides themselves.

Loss of heat takes place mainly in two ways, namely, in the escaping gases and by radiation. The loss of heat in the roasted ore leaving the furnace is very small. The heat units per ton of Broken Hill zinc concentrates are 5,780,500 B.T.U.s. Roasting down to 9% sulphur in the roasted ore the B.T.U.s liberated are 4,278,850.

The maximum temperature in the furnace is 900° C., and the total volume of gas at 6% SO_2 per ton of concentrates is 90,000 cu. ft. at S.T.P., and the heat required to raise this volume from normal temperature to 900° C. is 3,123,000 B.T.U.s. The B.T.U.s in the roasted ore leaving the furnace at 700° C. = 342,000 B.T.U.s. Then we have:

	B.T.U.s	%
Heat carried off in gas .	3,123,000	73·0
Heat carried off in roasted ore	342,000	8·0
Heat lost by radiation .	813,850	19·0
	4,278,850	100·0

As a matter of fact, however, the gas leaves the furnace at 700° C., having lost 200° C. in the top of the furnace by radiation, and by meeting the cold ore. The figures should therefore be:—

	B.T.U.s	%
Heat carried off in gas .	2,429,000	56·8
Heat carried off in roasted ore . . .	342,000	8·0
Heat lost by radiation .	1,507,850	35·2
	4,278,850	100·0

The more heat units that are liberated in the furnace per minute, the less will be the radiation factor, provided the temperature does not rise.

A furnace that will roast 36 tons per day down to 1% of sulphur (using coal, of course) will roast 70 tons per day down to 9% without fuel. The heat units liberated in the furnace in the latter case are 1·49 times the heat units liberated in the former case from the ore alone. This corresponds to 3·65 tons coal, or 10% on the weight of the ore (36 tons). This illustration brings out the great importance of speeding up the roasting to the utmost possible pitch so as to cut down on the radiation.

The percentage of SO_2 in the roaster-gas has a substantial bearing on the temperature inside the furnace. Clearly the lower the percentage of SO_2 in the roaster gas the larger the volume of the latter per ton of concentrates roasted, and consequently for the same temperature of gas the larger the number of heat units carried out of the furnace by the gas. Hence the theoretical temperature to which the roaster gas will rise varies directly with the SO_2 content as shown by the following figures:—

SO_2 content of Roaster gas per cent.	Theoretical Temperature degrees centigrade.
2	440
3	640
4	820
5	990
6	1,150
7	1,300

In actual practice the roast will maintain itself down to 9% sulphur or even lower if the gas strength does not fall below 5·6%, and the sulphur burnt per square foot of hearth area is not less than 14 lb. per 24 hours.

If low temperatures are allowed to prevail on the lower hearths, where the ore is partially roasted, the formation of zinc sulphate begins. This is marked about 800° C., and around the periphery of the hearth and on the hearth below the level of the rabble teeth is accompanied by a caking and hardening of the charge, which causes a good deal of trouble, as it has to be removed by hand barring in order to prevent the rabbles becoming jammed. This is particularly marked against the outer wall of the furnace, when the drop-holes are spaced too far apart, the shortage of oxygen and cooling effect of the outer wall combining to reduce temperature and increase stagnation of the SO_2.

In this connexion the addition of fresh, finely divided ore by means of air jets is of great assistance, by stirring up the atmosphere and keeping up the temperature. So also is the fact that we are only roasting down to 9% SO_2, the tendency to cool off increasing in proportion as the final roast is pushed further.

Lastly, and by no means of least importance, is the mode of introduction of the air. Clearly if all the air is passed into the furnace at the bottom hearth, we are absorbing heat by the air where we can least afford to spare it. By dividing the air and passing part of it directly into the hot upper hearths a much more uniform temperature can be maintained in the furnace.

(*b*) *Roasting on a Blast-Grate.*—Temperature control in this case can only be effected by varying the degree to which the pre-roast has been carried. The amount of fuel used as the igniter (about 0·6%) is too small to have any serious effect.

In blast-roasting, the radiation from the heart of the charge is very small compared to hearth-roasting. Consequently the temperature tends to approximate to the theoretical much more closely than in the case of hearth-roasting. The theoretical temperature which would occur if we roasted green concentrates in such a way as to use up all of the oxygen (giving an SO_2 tenor of 13·7% in the roaster-gas) would be 1,830° C. In consequence, it is not surprising to find that when attempting to roast green concentrates on a blast-grate, the operation was brought to an abrupt end by the fusion of the charge which rendered it impervious to the blast.

Consequently, before the blast-roast can be satisfactorily applied, it is necessary to first reduce the sulphur content to between 8 and 10% in the case of Broken Hill concentrates. Under these circumstances the ore grains are sintered together, giving a finely porous mass. The temperature reached is somewhere between 900° and 950° C., which corresponds with the SO_2 tenor of the gas of 4 to 5%.

The percentage of sulphur which can be left in the pre-roast depends largely on the purity of the ore, which again determines its fusibility. The Broken Hill concentrates, being rich in lead, iron, and manganese, have a low fusibility.

Temperature regulation on the blast-roast is therefore largely automatic, being based on the fusibility of the ore and the corresponding sulphur content of the pre-roast. Once these are established the temperature takes care of itself.

3. The Size of the Ore Particles.

(*a*) *Roasting on a Hearth.*—From what has been said under Section 1 (*a*), it is obvious that in hearth-roasting the fine particles will roast faster than the coarse. Experiments have shown that the through-160 material is roasted down to 9% between the third and fourth hearths, the through-60-on-160 between the fifth and sixth hearths, and the through-30-on-60 on the eighth hearth. This result could readily be foreseen from the arguments in previous sections.

There is, however, a point of interest in connexion with the introduction of through-160 material by the injector. This material, if injected at the fifth hearth, is found to roast at the same rate as the same size ore introduced into the top hearth; in other words, for the same number of hearths passed through, the through-160 ore roasts at the same rate whether introduced in the ordinary way or blown in.

In this connexion there is rather a curious fallacy prevalent among practical roaster-men, namely, that the ore in falling from one hearth to the next does a good deal of roasting during the fall. A moment's consideration will show the error. The oxygen-bearing gases are passing up through the drop-holes continuously, while the ore falls only at intervals as the rakes pass round. Allowing one raking in 90 seconds and 1 second for the ore to fall from hearth to hearth, even if the ore fell evenly through the gas rising through the drop-hole, it would meet only $\frac{1}{90}$ of the gas necessary to roast it. Further, as the ore runs over the lip of the drop-hole in a fairly dense stream the opportunity for contact between gas and ore is very small.

Fine particles will naturally have a better chance to roast through than coarse ones during the period of their sojourn at the surface of the charge, and will be less likely to be buried in a partly roasted condition at the next rabbling. Partly roasted grains are protected to some extent by the coating of oxidized material on their surfaces against further oxidation; while as the larger particles require to make contact with a larger volume of air, their chances of roasting through are less under conditions of poor ventilation than the fine ones.

(*b*) *Roasting on a Blast-Grate.*—The effect of size is less marked when roasting on the blast-grate than when roasting on a hearth. Obviously when a 9% sulphur material can be brought down to 1% in 14 minutes, the rapidity of the operation will mask variations due to the varying dimensions of the particles. Further, as the ore is sintered as it comes from the grate, screen tests intended to show up any difference of this kind are clearly impossible.

There are, however, certain points in this connexion which are of interest. In the first place it is quite certain that there must be a limiting size for the coarser particles, above which good roasting will be impossible. Twenty-mesh material works quite well; our experience with sizes larger than this is very limited, but the indications are that pieces in the neighbourhood of $\frac{1}{8}$ in. in diameter are getting very close to the limit. A good deal will depend on the type of zinc-blende concerned; as is well known, some roast much more freely than others.

It has been found that a proportion of exceedingly fine material is absolutely necessary to act as a binder on the coarser grains and prevent the charge running through the grate as it dries out. The pre-roast is moistened with about 10% of water before it goes to the grate, and unless there is sufficient plastic material present the layer on the machine will always form blow-holes, owing to the charge drying out and running through. If the ore does not contain sufficient material fine enough to be plastic, it is necessary to add about 2% of plastic clay, which is mixed well into the charge. Under these circumstances the charge holds together well and the trouble is avoided.

CONCLUSION.—As explained in the opening paragraphs, the object of this paper has been to lay down the principles which we have followed in the work of development rather than to go into the details of the practical working which has resulted, except in so far as is necessary for purposes of illustration.

To go into the practical details would make the paper unduly long, and can be more suitably dealt with later. In the meantime, it is hoped that what has been written may be of assistance, especially to those who are engaged in the development of roasting furnaces to meet present day conditions.

Jubilee of the Instution of Electrical Engineers.—It is just fifty years since the Society of Telegraph Engineers was founded, with an initial membership of 100. In those days the only practical application of the electric current was to telegraphy, and the first great engineering feat in connexion with electricity was the laying of the submarine cable in 1869. Afterward, electricity was applied to lighting, and subsequently to the transmission of power. With the expansion of the uses of the current, the society was broadened, and its name was changed to the Institution of Electrical Engineers. The present importance of this industry may be gauged by the fact that the Institution has 10,000 members, and that the privilege of possessing a royal charter is enjoyed. The jubilee of the founding of the Institution was celebrated by a series of special meetings held during the latter part of last month at the headquarters of the society on the Victoria Embankment. At the first meeting Dr. J. A. Fleming delivered a lecture on the many discoveries of Faraday, particularly that by means of which the motion of a magnet was made to create an electric current, a discovery which formed the basis of the development of the dynamo, and on his many other inventions in the realm of electrical science. A subsequent meeting was devoted to short addresses giving reminiscences of early electrical engineering work. Mr. R. E. Crompton told how he helped in the design and erection of a central electric light station at Vienna in the eighties, and Sir Alexander Kennedy gave an account of the early difficulties in introducing similar stations in England. An anniversary dinner was also held, at which many distinguished visitors were present. Dr. W. H. Eccles presided, and Mr. F. G. Kellaway, the Postmaster-General, was the chief speaker, proposing the toast of the Institution. He suitably drew attention to the wonderful developments of human endeavour due to the activities of the electricians.

MODERN MINE FANS

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(Concluded from February issue, p. 87.)

METHODS OF DRIVING THE FAN.—The two chief methods of driving a mine fan are by means of the steam engine or the electric motor. The steam engine may be vertical or horizontal and non-condensing or compound. The vertical engine is the more economical as regards floor space, and the speed is generally higher than that of the horizontal engine. If the fan is a large one, and the speed suitable for direct coupling to the engine, this is the most efficient arrangement. Often, however, the most suitable speed for the engine is not suited to the fan in order that the requisite volume of air be produced. In this event rope or belt gearing is the best means of connecting the engine to the fan. Compound condensing engines are, of course, the most efficient, and should be employed wherever possible. The cylinders may be placed side by side or tandem fashion, whichever is the more convenient. The engines should have forced lubrication, and the main bearings of the fan shaft should be large and well lubricated to prevent heating. An efficient governor is a valuable adjunct to the fan engine, ensuring steady speed under all conditions of loading. A speed recorder giving continuous indication of the revolutions of the fan is also a desirable feature, or in lieu of that an automatic continuously recording water-gauge should be used. The Coal Mines Act of this country requires the use of one of these alternatives. Where steam is being generated for other purposes as well, it will probably be as economical as any to drive the fan by means of a compound-condensing engine. On the other hand, electrical driving possesses many advantages, and is being adopted in an increasing number of instances. The electrical motor is compact, reliable, and efficient. In general, however, its speed is too high to enable it to be coupled directly to the fan. Slow-speed motors can be obtained, but they are bulkier and costlier than the high-speed motor of the same power. If the supply is direct-current a shunt-wound, or a lightly compounded motor will be found most suitable. If the power is alternating current, a three-phase induction motor of the squirrel-cage or slip-ring type is the best. All of those types of motors give a practically constant speed over a wide variation of loading. The starting arrangements in each case are simple, and if the motor is properly attended to when in operation, and is sufficiently large for its work, it is capable of running continuously for a very long period without breakdown. It should be remembered that a motor driving a fan is under "continuous rating" conditions of the severest form, for the fan must run night and day, week in, week out, without a stoppage. The motor should therefore be designed for continuous operation. On the other hand, there is probably no other duty where the load is so consistently steady as in ventilation. The variation of loading is small indeed, and thus the current taken by the motor is practically constant.

There is, however, the desirability of providing for the development of the mine. As time goes on and the underground workings become more extensive, the quantity of air necessary to maintain the mine atmosphere pure and cool will increase, and this will throw a greater load on the fan and consequently the motor. Either the motor must be designed to stand this increased duty or a larger motor must be substituted. A motor which is worked continuously at a loading greater than that for which it was designed must sooner or later break down. It is one of the inherent advantages of the electric motor that it can stand at any time a considerable overload, but this can only be safely done for short periods with intervals of less strenuous work intervening. Persistent overloading courts breakdown and serious damage to the motor. Any necessary reduction in the speed of the motor to suit that of the fan is best accomplished either through rope or belt driving, or by means of endless chain belts, a method which is becoming increasingly popular. If it should be necessary to increase the speed of the fan—as the result of the demand for more air—this can be done by decreasing the size of the pulley on the fan-shaft or increasing the size of that on the motor-shaft.

A good example of electric fan driving may be seen at the Bullcroft Main Colliery, near

Doncaster, where a Waddle fan is driven by a three-phase cascade-connected variable-speed motor-group. The motor set consists of a twelve-pole three-phase induction slip-ring motor, connected in cascade with a variable-speed squirrel-cage auxiliary motor, the speed of the latter being varied by varying the number of poles. By this arrangement variation of speed can be obtained more economically than is usual with alternating current installations.

Failing steam or electric power, the fan may be driven by gas or oil engine or by water-power.

Surface versus Underground Fans.—By reason of legal restrictions, ventilating fans at collieries in this country are invariably situated at the surface. Sometimes fans are installed underground, but these are generally ancillary to the main fan, which is placed at the top of the upcast shaft. The chief reason for the restriction forbidding the placing of reliance for the ventilation of the colliery solely on underground fans is the risks involved through possible explosions, which would probably destroy the fans and render the subsequent rescue or recovery work extremely difficult. This risk is non-existent in a metalliferous mine, and in many cases, in South Africa for example, ventilators are placed not on the surface but in some part of the workings. For instance, at the Simmer Deep mine, one of the deepest mines on the Rand, having a vertical depth of 5,000 ft., a large double-inlet Sirocco fan was installed at a depth of 2,000 ft. below the surface. Similar fans are to be found at the Robinson Deep and Jupiter mines, and others on the Rand. One of the advantages attached to the underground fan is that surface leakage is eliminated. When an exhausting fan is installed at the top of the upcast shaft a considerable amount of air is drawn through the covering doors of the shaft, and the same form of leakage takes place at the top of the downcast shaft, where a blowing fan is used, a part of the air blown into the shaft escaping through the shaft covers instead of going down the shaft to the workings. The leakage caused in these ways is often very great, if the covered shaft is used for winding.

If the fan is placed at the bottom of either the downcast or the upcast shaft, however, neither of the shafts has to be covered at the top, and although a certain amount of leakage through separation doors takes place, the loss is much less than if the fan were at the surface. If the banking level is totally enclosed by an efficient air-lock, the leakage at the surface enclosure is reduced to a minimum. Where both shafts are used for hoisting purposes it is a great advantage to have the top clear of covers or enclosures.

On the other hand, in addition to the explosion risks, there remain such objections as (*a*) the cost of underground excavations to accommodate the fan and its motor, (*b*) the additional doors required, (*c*) the risk of fire and the difficulty of dealing with such an outbreak, and (*d*) the possibility of not being able to attend to the fan and the ventilation if the hoisting gear be thrown out of use for any cause. On the whole, apart altogether from legislative enactments, it is much better and safer to have the main ventilating plant at the surface, particularly in a coal mine.

Underground Fans or "Boosters."—It has become the practice in many mines to install secondary or auxiliary fans underground for the purpose of "boosting" the ventilating current, either for the whole mine or in a particular district, where the current is normally sluggish. Generally those fans are small and driven electrically at a relatively high speed. They are not intended to take the place of the main ventilator, which is situated at the surface, but simply to act as a pressure booster, where they are considered necessary. In many mines great difficulty is often experienced in correctly and equably distributing the air-current over the different districts. Workings near to the shafts naturally form an easier path for the air than workings more remote. It is often an unsatisfactory remedy to restrict the quantity flowing into the near districts in order to cause a larger volume to travel into the more distant workings. Regulation of this kind always results in a reduction of the total quantity of air flowing into the mine, as the additional quantity passing into the unregulated parts is always less than the reduction of volume in the regulated districts. Consequently in cases where none of the districts is getting more air than is needed while some are inadequately ventilated, it is often necessary to boost up the pressure in the latter by means of small electrically driven fans, as this method adversely affects the volume flowing into the other parts to the smallest possible extent. A Jeffrey booster fan is shown in Fig. 13. The fan is belt-driven by an electric motor. Where compressed air is the chief underground motive power, the most economical and efficient mechanical ventilator is the "Typhoon" blower, an illustration of which is given in Figs. 15 and 16. The feature of this machine is the rotor, which is a combination of the driving turbine with the fan *4* to form one unit. This rotor is fitted to an inner casing *12* with a stationary hollow cast-steel shaft *7* round which the rotor revolves on ball bearings *5*. Round the periphery of the fan blades are flanges to which is attached a bronze ring *1*, and on this ring are mounted the drop-forged steel buckets which form the turbine portion of the machine. The bronze bucket-ring revolves truly between machined facings so that there is no possibility of leakage, and the full power of the compressed air, delivered by means of three gun-metal nozzles *2*, is expended upon the turbine buckets. The compressed air impinges directly on the turbine buckets. The exhaust mingles with the delivery and so assists the ventilation current.

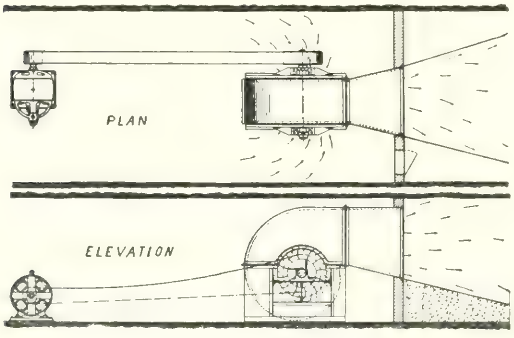


Fig. 13.—Jeffrey Booster Fan.

Exhaust versus Blowing Fans.—The majority of mine fans are arranged to suck or exhaust the air from the mine. In this way a depression is produced which provides the necessary circulation of air. Sometimes, however, it is preferred to blow or force the air into the mine. In the former case the fan is placed at the outlet, and in the latter case at the inlet of the mine. So far as the circulation of a given quantity of air in the mine is concerned, it is of little consequence whether the fan exhausts or blows the air. It is usually more convenient to place the fan at the top of the upcast so as to keep the downcast shaft, which is generally the winding shaft, clear of surface obstructions.

The forcing of air into the mine raises the atmospheric pressure there above that corresponding to the barometric pressure, whereas the exhausting fan reduces the atmospheric pressure in the mine. Unless the mine has a high water-gauge, the difference of atmospheric pressure between forcing and exhausting is small. For example, if the water-gauge for the mine is 3 in., the difference between forcing and exhausting would be equivalent to less than ½ in. of the mercurial barometer. If, however, the mine water-gauge is high, say 14 in. — an exceptionally high value, but not impossible —the difference would equal 2 in. of mercury.

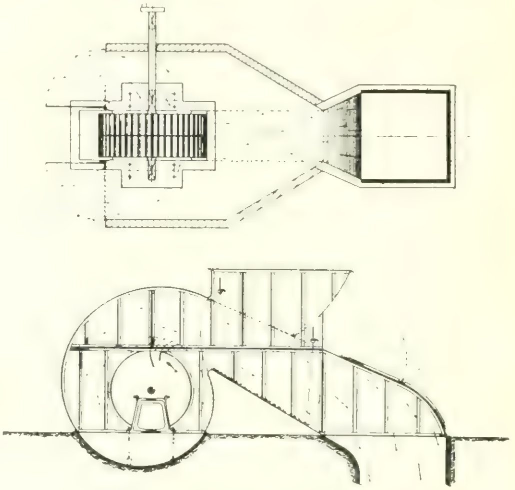


Fig. 14.—Jeffrey Fan arranged for Blowing.

In a mine of such high resistance, the effect of a sudden fall of the barometer would be appreciably less with a blowing than with an exhausting fan. Further, the increased density of the air in the mine would effect to some extent the rate of emission of gases from the coal or rocks and the drying and cooling power of the air. On the whole, however, the choice of blowing or exhausting fans is chiefly a matter of expediency or suitability. Fig. 14 shows a Jeffrey fan arranged for blowing.

Fans in Combination.—At many of our British collieries and at some of the more important metalliferous mines duplicate fans are installed, one of which is designed to act as a standby for the other. This is an excellent arrangement at an important mine, and forms an ample safeguard against a stoppage of the ventilation. In many instances, instead of installing two fans there is one fan only, and a spare method of

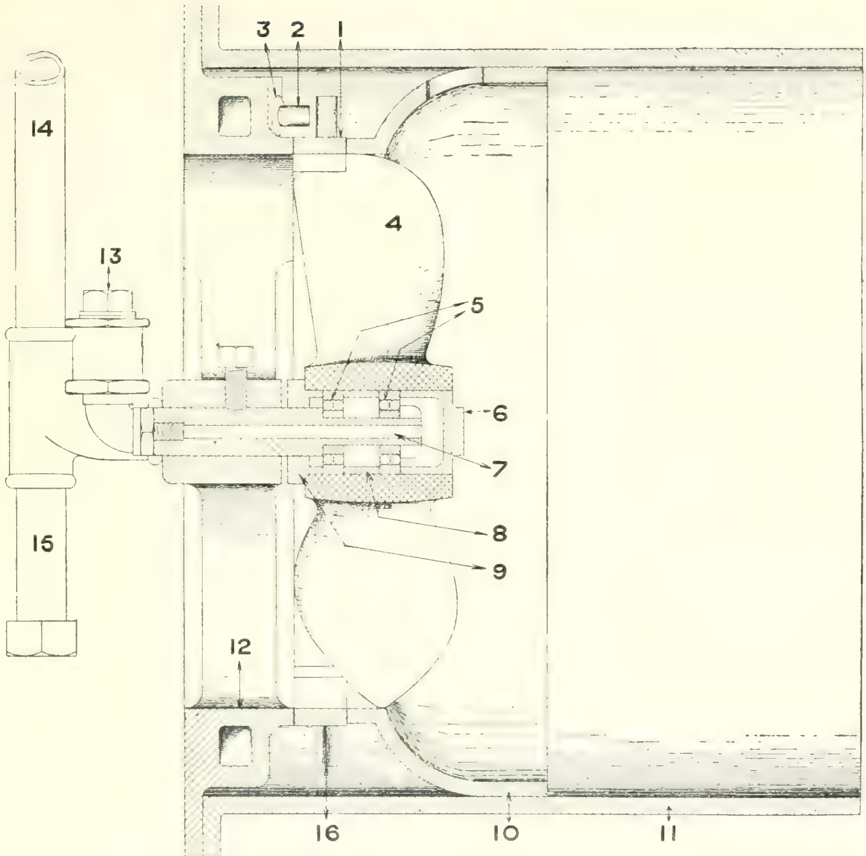


Fig. 15.—Longitudinal Section of Turbon Booster Fan.

1. Bucket ring; 2, nozzle; 3, nozzle nut; 4, propeller; 5, ball bearings; 6, plug screwed r.h.; 7, hollow shaft; 8, distance bushing; 9, retainer screwed l.h.; 10, muffle ring; 11, outer casing; 12, inner casing; 13, grease cup; 14, supply pipe; 15, scale catcher; 16, turbine vanes.

driving the fan is provided. The engine or motor driving the fan is much more liable to break down than the fan itself, which, if strongly built, as most modern fans are, may be relied upon to run for long periods without stoppage, provided the lubrication is good. The ventilation of the mine is a matter of prime importance, and there must be adequate provision against breakdowns. Where the fan is electrically driven, it is a simple matter to have another motor as a standby, ready to be put in the place of the machine which ordinarily does the work. Sometimes in the case of double-inlet fans, the fan-shaft is prolonged and fitted with a spare rope or belt wheel, or, if not, the wheel is kept in readiness to be put on at any moment. The spare motor is fixed in position to drive the fan from that side. In this way the change over to the other fan can be made with a minimum of delay. It is a good plan to have the duplicate driving plant of such

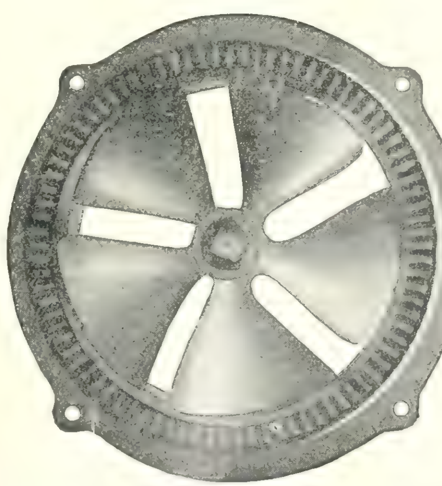


Fig. 16.—Rotor and Inner Casing of Turbon Fan with Outer Casing removed.

a permanent nature that the two units can be put to use in rotation, thus ensuring that one is not overworked while the other is standing idle, and that both are kept in good working condition. The best arrangement of all is, of course, to have two complete fan installations and to run them alternately, say once a month. Sometimes two fans are run in series or in parallel in order to increase the volume of air in circulation, but as a rule this is not advisable.

FACTORS GOVERNING INCREASED VENTILATION.—Once a fan has been installed at a mine there are only two ways in which the quantity of air circulated in the mine may be increased. Those are: (1) by increasing the speed of the fan, and (2) by reducing the resistance of the mine. The following performances of a 119 in. diameter Sirocco fan were supplied to the author by the makers:—

Revs. per min.	Volume cu. ft. per. min.	Water-gauge Inches
253	400,000	8
238	373,000	7
219	346,000	6
200	316,000	5
179	284,000	4
156	245,000	3
128	200,000	2

The fan was designed to work on an equivalent orifice of 56 sq. ft. The author tested this fan on duty in July, 1920, and found it to give 111,000 cu. ft. per minute on a mine equivalent orifice of 21·6 sq. ft. This result corresponds very closely to what would be expected from purely theoretical considerations. The speed of the fan when tested was 175 revolutions per minute, and the fan-drift water-gauge 4 in.

From inspection of the above table, it will be seen that for a given mine resistance the volume of air circulated by a fan is almost directly proportional to the speed, that is, an increase of speed of say 20% will give an increased quantity of approximately 20% also. Increase of speed, of course, implies increase of water-gauge, and this may be undesirable because of the increased tendency to leakage at doors, air-crossings, stoppings, and brattices.

The most profitable way to increase the ventilation of the mine is by reducing the resistance of the mine, or, in other words, increasing the area of the equivalent orifice of the mine. There are several ways in which this may be done. The formula connecting the quantity with the pressure and the factors which constitute the mine resistance are given by the equation,

$$Q^2 = \frac{p\,a^3}{ks} \text{ or } Q = \sqrt{\frac{pa^3}{ks}}.$$

In this formula Q = quantity in cubic feet per minute, a = area of cross-section of the airway, s = rubbing surface of the airway in square feet, and k is the coefficient of friction. Assuming p and k constant, we have Q proportional to the square root of a cubed divided by s, or written symbolically

$$Q \propto \sqrt{\frac{a^3}{s}}.$$

Taking a circular airway, $a = \frac{\pi d^2}{4}$ and $s = \pi d l$, where l = length of airway. Consequently, $Q \propto \sqrt{\frac{\left(\frac{\pi}{4}\right)^3 d^6}{\pi d l}}$. Leaving out all the constants and assuming l constant, $Q \propto \sqrt{d^5}$.

From this it can be readily shown that an airway 10 ft. diameter will pass nearly six times as much air as an airway 5 ft. diameter, other things being the same in the two cases. What obtains in the circular airway holds whatever the shape of airway. Thus one way to increase quantity without speeding up the fan is to increase the cross-sectional area of the airways. This cannot always be easily done, however, especially in the case of shafts, but the principle involved should not be lost sight of when the shafts and main airways are being constructed in the early days of the mine. Afterwards much good may result from a policy which insists on the maintenance of sufficiently large airways in the chief districts of the mine. By the judicious rearrangement of districts the length the air has to travel may often be considerably reduced, with a beneficial effect on the ventilation. The most important means of increasing the ventilation, however, is "splitting". This means the division of the mine into a number of separate districts, each of which is ventilated by a separate portion of the air-current. To obtain the greatest benefit from splitting, the air-current should be subdivided as near to the bottom of the downcast shaft as possible, and the various splits reunited close to the bottom of the upcast shaft. The splits should be as nearly equal as possible, as if some are much shorter or much longer than others regulation is necessary on the short splits, and this tends to reduce the total quantity of air entering the mine. If it becomes necessary at any time to increase the quantity of air in a mine without increasing the speed of the fan, consideration should be given to the number and arrangement of the ventilating districts. It will be found in many cases that additional splits or a readjustment of the existing districts will enable the fan to greatly increase the air-circulation.

Splitting cannot, of course, with advantage be carried out to an indefinite extent. A point is reached when further splitting is unaccompanied by increase of ventilation, but in most mines it will be found that this limit is still fairly remote.

When the volume of ventilation gives cause for anxiety, close attention should be given to leakage. Reduction of leakage must inevitably increase the effective circulation in the working places. Before leaving this phase of the subject it may be pointed out that it is cheaper in power expenditure to obtain increase of quantity by lowering the resistance of the mine by some of the devices mentioned than by increasing the speed of the fan.

THE EFFICIENCY OF A VENTILATOR.—The overall efficiency of a fan is measured by the ratio,

$$\frac{\text{Horse-power in the air}}{\text{I.H.P. of engine or E.H.P. of motor.}}$$

The horse-power in the air is got from measurements of the quantity of air circulated in the mine and the ventilating pressure for the mine. The quantity and pressure are measured in the fan-drift, and the horse-power is given by $\frac{Q \times W.G. \times 5 \cdot 2}{33{,}000}$ where Q = cubic feet of air circulated per minute, and $W.G.$ = inches of water-gauge. The horse-power of the engine is obtained by measurements of the steam pressure, piston speed, and size of the cylinders, and the input to the electric motor can be calculated from the voltmeter and the ammeter readings or the reading of the wattmeter.

About 60 to 70% is considered a good value for the overall efficiency of a fan. The efficiency is influenced by: (*a*) the mechanical efficiency of the engine or motor, (*b*) the mechanical efficiency of the fan, (*c*) the orifice of passage of the fan, (*d*) the equivalent orifice of the mine.

The equivalent orifice of a mine is an opening in a thin plate of such an area that it would offer the same resistance to the passage of air as the mine itself offers. Similarly the orifice of passage of the fan is an opening having the same resistance as the fan passages.

The ratio of the equivalent orifice to the orifice of passage has an important bearing on the efficiency of a ventilating system. The most favourable relation exists when the size or area of the orifice of passage of the fan is from two to three times the area of the equivalent orifice of the mine. Another, and in the present writer's opinion, a better method of comparing the two, is to employ the equivalent resistances of the mine and fan as expressed by the ventilating pressure required to send a given quantity of air through them. In this mode of comparison the resistance of the mine should be from four to nine times the resistance of the fan itself. If the resistance of the fan is more than one-fourth of the resistance of the mine,

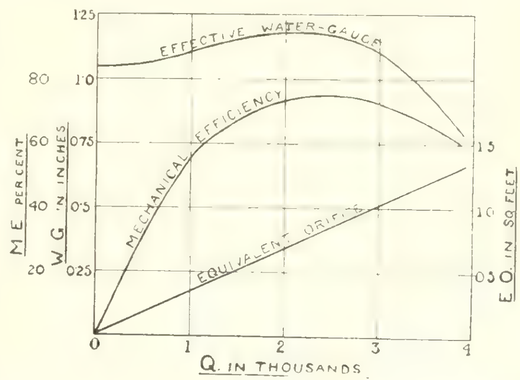


FIG. 17.—CURVES OF WATER-GAUGE, MECHANICAL EFFICIENCY, AND EQUIVALENT ORIFICE.

the latter is too small for the mine. On the other hand, if the resistance of the fan is less than one-ninth of the mine's resistance, too large a fan has been installed. Of course, in view of probable future developments, it is often advisable to install a much larger fan than present requirements demand, and this desideratum would necessarily modify the foregoing statements.

Fig. 17 shows curves of water-gauge and mechanical efficiency, together with the equivalent orifice of the mine, plotted against the quantity of air in thousands of cubic feet per minute. The experiments from which the curves are plotted were carried out by the writer on a $12\frac{1}{2}$ in. diameter

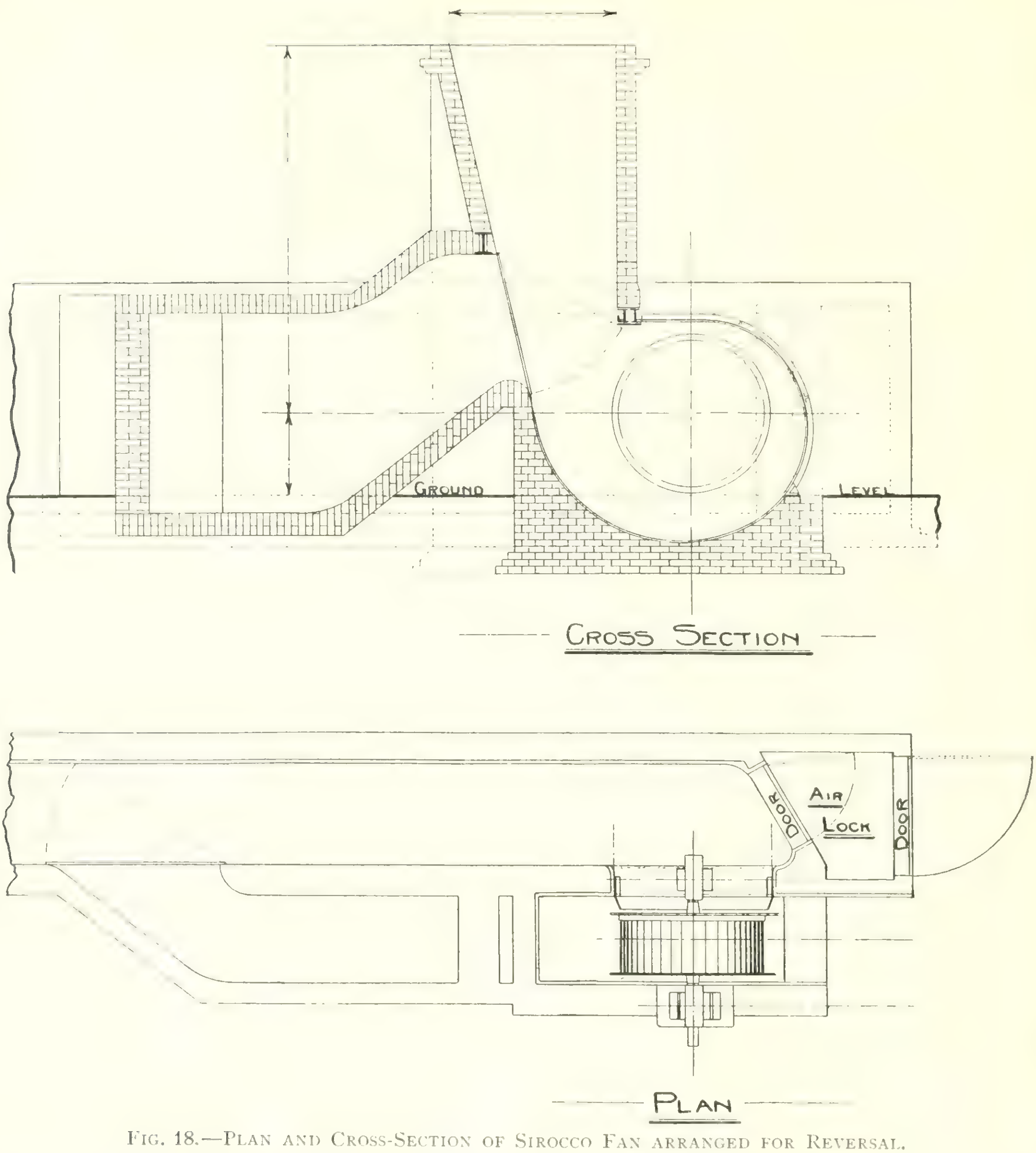


Fig. 18.—Plan and Cross-Section of Sirocco Fan arranged for Reversal.

Keith fan, running at a uniform speed of 900 revolutions per minute.

In general, a mine fan will operate during the life-time of the mine over a considerable range of variation of mechanical efficiency. For example, if a large fan is installed at the opening of a mine, the efficiency at first will be low, but as the mine develops and the quantity of air circulated by the fan increases, the value of the mechanical efficiency will improve. Through course of time the maximum efficiency for the conditions may be obtained.

Reversing the Air.—The Coal Mines Act of 1911 requires that where a mechanical ventilator is employed provision shall be made for reversing the direction of flow of the air-current in the mine. Such reversal might be necessary in the case of an explosion of fire-damp or coal-dust or in the event of a large underground fire. There are several ways in which a reversal of the ventilator can be effected. One way is to install a blowing or forcing fan at the top of the upcast in addition to the exhausting fan which normally ventilates the mine.

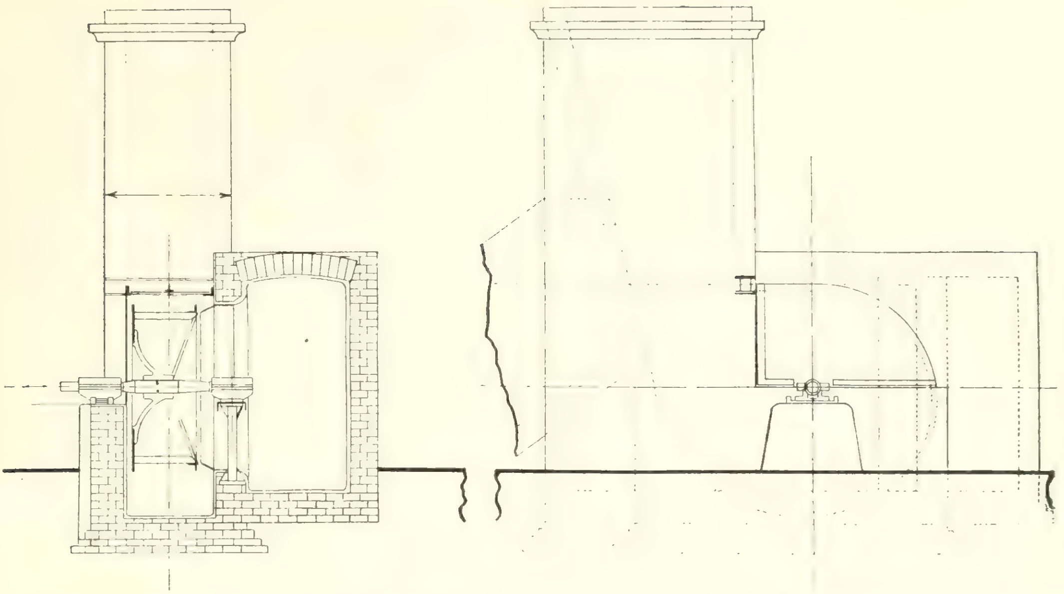


Fig. 19.—Longitudinal Section and End Elevation of Sirocco Fan arranged for Reversal.

When reversal of the air is to be carried out the exhausting fan is slowed down, stopped, and doors in the fan-drift closed so as to shut the fan off from the shaft. The blowing fan is now started, doors being opened so as to place it into communication with the upcast shaft.

All modern fans may be so arranged as to become exhaust or blowing fans at will, and where only one ventilator is installed this is the best arrangement. A Sirocco mine-fan arranged for reversal is shown in Figs. 18, 19. Normally, the fan exhausts from the mine. When reversal is to be done, the fan is converted into a blowing fan by raising a hinged door so as to close the " evasee ". At the same time the opening of this door allows the fan to discharge its air through the back of its casing into the fan drift. Side doors are opened which allow the fan to draw its inlet air through the air-lock, straight from the atmosphere. Two doors in the fan drift close the ordinary inlets to the fan, and allow the fan to discharge into the upcast shaft, which now becomes for the time being the downcast.

Conclusion.—In concluding this brief article, I desire to thank various makers of fans for information given and for illustrations lent ; also to thank Messrs. Charles Griffin & Co., Ltd., for permission to use certain illustrations.

Canadian Institute of Mining and Metallurgy.—The twenty-fourth annual meeting of the Canadian Institute of Mining and Metallurgy was held at Ottawa on March 1, 2, and 3. After Mr. C. V. Corless had delivered his presidential address, a number of papers were presented. Of these papers those on mining and milling at the Hollinger and McIntyre gold mines at Porcupine attracted much attention. Other papers dealt with the recovery of precious metals from Sudbury nickel ores, by R. L. Peek, the Ontario gold deposits, by Percy E. Hopkins, and prospecting conditions in Northern Manitoba, by R. C. Wallace. The report of the Institute for the year 1921 showed a slight increase in membership at 1,620. The revenue was $13,117 from subscriptions, $3,623 from publications, $1,580 from dividends and interest, and $3,000 from the Dominion Government, but expenditure and liabilities were $5,441 in excess of the total income, owing to the policy of expansion lately adopted. The Institute, however, has ample funds to continue this policy.

THE IRON ORES OF YUGO-SLAVIA

By D. A. WRAY, M.Sc., F.G.S.,
Geologist to the British Mission to Yugo-Slavia in 1919

INTRODUCTORY. — Yugo-Slavia, Greater Serbia, otherwise the kingdom of the Serbs, Croats, and Slovenes, constitutes one of the newly formed states of south-eastern Europe, consequent on the terms of the peace treaties. Prior to the Great War Serbia was a minor state, being about the same size and having the same population as Ireland. By incorporating states formerly included within the Austro-Hungarian Empire, it has so increased in size as to become one of the principal powers of the Near East. Its total area is now estimated at about 87,000 square miles, or about the total area of Great Britain. In Yugo-Slavia are incorporated almost the entire lands inhabited by the Southern Slavs, including the Serbs, Croats, Slovenes, Bosnians, and Montenegrins, who have the closest racial affinities to one another. The several states are Serbia, Serbian Macedonia, Slovenia, Croatia, Slavonia, Baranja, Bosnia, Herzegovina, Dalmatia, and Montenegro. Under Austrian Imperial diplomacy these closely allied peoples were kept apart, and the successful inauguration of the triune kingdom ends for all time, it is hoped, the German dream, "Drang nach Osten," of ever extending expansion and penetration south-eastwards into the Balkans and the Near East.

With the exception of the more north-western portions, Yugo-Slavia is pre-eminently an agricultural country. Its mineral resources have been comparatively little developed, and what has already been accomplished in this direction is largely due to Teutonic enterprise. It now offers an attractive field for British interests, whose friendship and assistance are warmly welcomed.

Up to the present time an important British company has been working the famous Misitsa lead mines, near Bleiburg, in Slovenia; while British companies are conducting investigations of the oil resources of Croatia, which are believed to be of a promising nature. The several iron-ore fields are not at present being worked, though they appear worthy of further attention and investigation.

The principal districts in which iron ore has already been mined are in Bosnia. No ore, however, is being worked at present, though the Austrian military authorities opened out extensive workings at Ljubia in north-western Bosnia during the war.

An estimate of the total iron-ore reserves of Bosnia has been made by Dr. F. Katzer, the Government Geologist.[1] In all, these are considered to amount to twenty-two million metric tons, made up as follows :—

	Tons
Siderites . . .	3,500,000
Limonites . .	15,000,000
Hematites . .	3,000,000
Magnetites . .	500,000

This estimate is based on the iron-ore deposits which have been exploited. A widely varying estimate was, however, given by Dr. Nottmeyer in 1910,[2] who considered the potential reserves of one iron-ore field alone (that of Vares, near Sarajevo) to amount to one hundred million metric tons. While this estimate may be unduly optimistic, it is probable that if the untouched ores of Bosnia are included with Dr. Katzer's estimate, the total reserve tonnage may safely be computed at thirty to forty million metric tons.

Bosnia, relatively speaking, is the richest of all the Balkan States in iron-ore reserves, with the possible exception of Greece. The Bosnian deposits are, however, much more uniform in character and composition than the latter. Iron ore has been mined on a small scale in Slovenia and Croatia, but the resources of these provinces would appear to be comparatively unimportant. Those of Dalmatia, Herzegovina, and Slavonia are insignificant.

Iron ore occurs in numerous localities in Serbia, Serbian Macedonia, and Montenegro, but with the exception of the Majdanpek mines in north-eastern Serbia, are of small extent, and have yielded very little ore up to the present time. In any case the lack of transport renders them of little immediate importance.

BOSNIA.—The iron ores of Bosnia consist in the main of siderites, together with limonites and hematites, which have resulted from their alteration. At Vares, the principal centre, they belong to the Triassic formation,

[1] F. Katzer: *Die Eisenerzlagerstätten Bosniens und der Hercegovina*, Sarajevo, 1910, pp. 1–334.

[2] "The Iron Ore Resources of the World," International Geological Congress, Stockholm, 1910, p. xxxiii.

while at Ljubia, where they were opened up by the Austrian military authorities during the war, they occur in Carboniferous rocks. Magnetite occurs sparsely in association with basic eruptive rocks in several places.

Vares District.—This iron-ore mining district covers an area of about 3 square miles around the little town of Vares, 16 miles north of the station of Podlugovi, on the main Sarajevo-Brod railway, to which it is connected by a light railway. This railway, following the picturesque and tortuous valley of the Stavnja, has a circuitous course and many high gradients, rising nearly a thousand feet in passing from Podlugovi to Vares. Vares is about 25 miles north of Sarajevo.

The iron industry was founded here in 1846 by a Turkish pasha, and had a considerable reputation during the Turkish occupation, when the charcoal iron was sent as far distant as Asia Minor and Egypt. At that time pack-horses were the sole means of transport for the ore from the mines, the charcoal from the forests, and the iron bars and finished products to the surrounding centres. At that period the plough-shares, cooking utensils, and other hardware goods from Vares were held in high repute at most of the bazaars in south-eastern Europe.

The numerous primitive furnaces and water-driven hammers, known collectively as "majdans," some of which were working until comparatively recently, are relics of the former activities of the Turks. At one time upwards of fifty such small plants were in operation at Vares alone.

The majdan consists of a small furnace, built of stones, clay, and woodwork, 16 feet high, and with an average diameter of 3 feet. Two pipes enter it at the base to supply the blast of air from bellows worked by a water-wheel. The furnaces were charged with iron-ore and wood fuel, and gave on an average one ton of pig iron daily. The pig iron came out in part with the scoriæ, and in part remained in the bottom of the furnace. The latter product was much preferred, as by the continual action of swiftly moving hammers driven by water-power it lent itself directly to treatment. These simple high-bloomery furnaces can, however, only be lighted twice a week, as they collapse consequent on each smelting, and about three days is usually occupied in rebuilding them.

The majdans are now almost a thing of the past, though a good many form picturesque sights in the Upper Stavnja valley around Vares, where horse-shoes, nails, and typically

Turkish utensils of commerce are forged just as of old. They are very seldom employed now to obtain the pig iron, which is obtained direct from the State furnaces at Krapuli, near Vares.

The Austro-Hungarian occupation of Bosnia in 1878 at first led to the abandonment of the iron industry at Vares ; but in 1890, the Austrian Government reopened the iron-ore mines at Przitsi, and built a small furnace at Krapuli, the terminus of the light railway, 1½ miles south of Vares.

The iron ore, which is mainly hematite, occurs in a number of irregular lenses, some of which are continuous and extend in an east and west direction over 3 miles. In this district, the Triassic limestones, dolomites, and shales are inverted, and rest on the Jurassic rocks ; the base of the iron ore is everywhere a thrust-plane, highly inclined, resting on the Jurassic limestones. The ore, which appears to be of metasomatic origin, occurs on the horizon of the Muschelkalk limestone. In places the Werfen shales intervene between the thrust-plane and the Jurassic limestones. It is covered, and in part interbedded with, Triassic limestones and dolomites. Red hematite, with 38 to 65% of iron, is mainly exposed in the higher workings, but in depth it passes insensibly into siderite or chalybite. Poechite, a variety of hematite rich in manganese, and brownish-black in colour, occurs in pockets in the hematite.

The principal mines from which the ore is obtained, mainly by open-cut workings, are at Smreka, Drozkovats, Brezik, and Przitsi. The Brezik and Przitsi mines are 2½ miles distant from the main central works at Krapuli, while the difference in level is nearly 1,300 feet. The Drozkovats and Smreka workings are 1¼ miles distant from Krapuli. From these numerous workings, scattered over the hills around Vares, the ore, after being broken, is lowered to a main level by inclined rail and ropeways. These are all connected to the main collecting station by a 55 centimetre tramway, and also a long underground road, the "Franz Josef" level, fitted with electric haulage and lifts to the subsidiary collecting stations.

At Smreka there are five main stages, each 40 ft. high in the open-cut workings, revealing in all a face of 120 ft. of iron ore. It is estimated that there is about 680,000 tons of ore in sight here. Generally speaking, the higher workings are in hematite, and the lower levels in limonite. Much alumina occurs at times, and stringers of barytes are occasionally met with. The average iron content of the ore ranges from 38 to 50%.

At Drozkovats there are twelve working stages, which vary in height from 20 to 50 ft. The total face of ore exposed is about 240 ft., of which the upper third is hematite, while the remainder is mainly siderite and limonite. About three million tons of ore has been opened up here, and the reserves are large. The average iron content of the ore varies from 39 to 48%.

At Brezik there are fourteen stages, showing a total face of ore of about 460 ft. The upper nine stages have been exploited extensively, but the lower five stages should contain large reserves well worth extraction.

Other important workings in the neighbourhood of Vares occur at Slatina, Potoci, Borak, and Ponikva.

Analyses of some of the Vares iron ores are given in the table below.

The total reserves in the Vares iron-ore mines are estimated to be at least fifteen million tons, and are possibly considerably more.

In the year prior to the war about one thousand men were employed at Vares iron mines and the adjoining ironworks of Krapuli, about half that number being engaged in mining. A colony with school, hospital, etc., is provided for the workmen,

The total annual production prior to the

ANALYSES OF VARES IRON ORES.

	Iron.	Manganese.	Silica.	Lime.	Magnesia.	Alumina.	Barium Oxide.	Sulphur.	Phosphorus	Copper.
Red hematite, Przitsi	65.07	0·53	4·14	0·48	0·26	1·00	—	0·04	--	0·01
Red hematite, Przitsi	61·20	0·11	6·05	0·35	-	0·68	3·00	0·16	0·06	—
Brown limonite, Brezik ...	48·70	2·00	6·28	0·70	0·39	1·35	3·03	0·12	0·25	0·26
Red hematite, Drozkovats.	54·30	2·53	11·20	1·83	1·74	2·20	0·85	0·23	0·31	0·01
Brown siderite, Drozkovats	45·90	5·08	6·55	—	--	—	—	0·30	0·02	0·02
Brown siderite, Drozkovats	57·66	6·17	7·04		not determined			0·01	0·02	0·08
Red hematite, Smreka....	40·37	11·25	10·15	-	—	—	—	0·06	0·26	0·05

war was approximately two hundred thousand tons, the greater portion of which was smelted at Krapuli. The remainder was exported via Metkovits and Brod to supply the blast-furnaces of Trieste and Resicza-Banja respectively.

The Vares ironworks and mines were formerly owned by a private concession, the Vares Iron Industrial Company, with a subscribed capital of four and a half million kroner; but in January, 1895, the Bosnian Provincial Government took over the workings in consideration of a rental of 231,055 kroner, the company to participate in any trade surplus to the extent of two-thirds.

Ljubia District.—Ljubia is 8 miles south of the railway station of Pryedor, and about 30 miles north-west of the town of Banjaluka, in north-western Bosnia. It is connected with Pryedor by a mineral railway, built by the Austrian Government during the war. The iron deposits of Ljubia, occurring in the Adamusa Mountains, are probably the most important in Yugo-Slavia, but prior to the construction of the railway transport was very difficult. Nevertheless, large slag heaps at the foot of the mountains bear witness to the large extent of the old workings, which are ascribed to the Middle Ages.

The ore consists in the main of spathic iron ore and limonite, occurring in three main beds, in shales, sandstones, and thin limestones of Carboniferous age. The ore-body is from 200 to 300 ft. thick at Ljubia, and extends southwards past Sanski Most, covering an area of about 16 square miles.

In the Javorik mine, or principal workings close to Ljubia, eleven main open-cut stages, each about 15 ft. high, have been dug in the ore-body, and six digging machines are installed for removing the cover. The two principal stages are each fitted with electric haulage, etc., and from these the ore is taken by tramways to a central collecting station at the foot of the hills where bunkers of 2,000 tons capacity have been installed. A main underground gallery has been commenced to link up the workings on the neighbouring hills. The mine was opened by the Austrian Government in 1917, and for about seven months in 1918 five thousand prisoners of war were employed. About 1,000 tons of ore was mined daily, and forwarded by rail to the blast-furnaces at Resicza-Banya and other centres within the former Austro-Hungarian Empire. Work ceased on the evacuation of the district by the enemy, and little has since been done. An ambitious scheme has been drawn up, and it is the eventual intention of the provincial Government to build a large permanent camp here, and eventually to install furnaces for smelting the ore in the immediate vicinity of Pryedor.

At Javorik workings, Ljubia, about three and a half million tons of ore are in sight, and the resources are considered to be very large. The ore contains upwards of 60% iron.

Other localities in this district where the bed has been worked are Stari Rieka, Adamusa, Drenovats, and Stari Majdan. Further south it has been mined in the neighbourhood of Sanski Most, and at Jazevats, Prevja, and Keska Ruda. Herewith are given partial analyses of some of the Ljubia iron ores.

There are several other localities where iron ore has been mined on a small scale in Bosnia. At Blagaj, 10 miles west of Pryedor, in north-western Bosnia, a similar ore-body to that of Ljubia, but of less extent occurs. It is situated close to the Banjaluka-Sunja railway. Various traces of old Roman workings occur in the district, and the scoriæ of the old workings cover an extensive area.

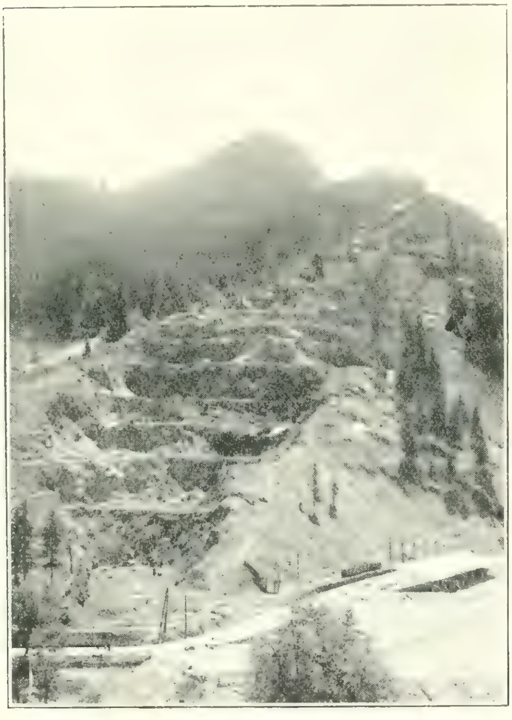
In Central Bosnia, at Sinjako, near Varcar Vakuf, 6 miles west of Jajce, a brown iron-ore deposit occurs interbedded in Carboniferous rocks, and has been worked on a small scale. Fojnitsa, in Central Bosnia, 30 miles north-west of Sarajevo, is the centre of another ancient iron-ore mining district. Both red and brown iron ores occur in the

ANALYSES OF CHARACTERISTIC LJUBIA ORES.

	Brown Limonite, Jazevats Workings. %	Brown Iron Ore, Javorik Workings. %	Brown Iron Ore, Jasle, Adamusa. %	Brown Iron Ore, Zofa, Adamusa. %
Iron	49·12	55·97	50·18	59·43
Manganese	2·37	2·28	1·30	2·68
Silica	13·75	7·64	10·00	2·80
Phosphorus	0·161	0·23	0·266	0·221
Sulphur	0·054	trace.	0·018	0·026

Palæozoic limestones here. At Srebrenitsa, in Eastern Bosnia, 50 miles north-east of Sarajevo, small deposits of iron ore have been worked. They occur in association with silver-bearing lead and zinc ores, but do not appear to be of any great extent or economic importance.

Ironworks in Bosnia.—The modern iron-smelting industry in Bosnia dates from 1890, when the Austrian Government built a small blast-furnace at Krapuli, a mile south of Vares, to smelt the ores mined in this district.



Iron Ore Mine, Drozkovats, Bosnia.

At first about 600 tons of ore were mined annually, and only charcoal iron was then produced. The Krapuli ironworks now consist of two fairly large blast-furnaces and an adjoining foundry. One of the furnaces, built in 1899, is especially fitted for the consumption of charcoal fuel. It is about 70 ft. high, and has a capacity of 6,000 cu. ft., yielding upwards of 100 tons of pig iron daily, probably the largest obtained anywhere solely from a charcoal blast-furnace. The fuel is entirely drawn from the magnificent beech and pine forests which cover the neighbouring hills.

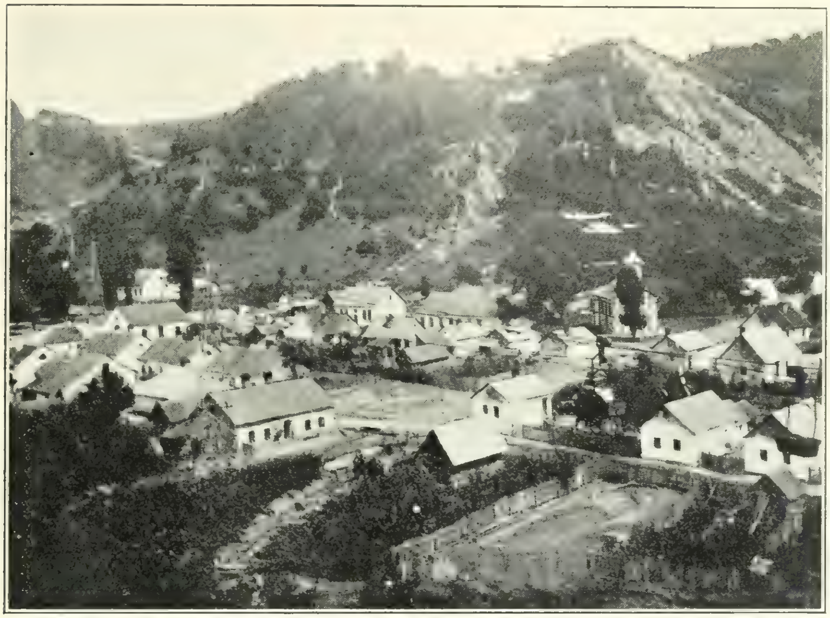
With the development of the Vares iron-ore field, and coal mines at Zenitsa, 25 miles north-west of Sarajevo, ironworks were established at the latter locality in 1894. The Zenitsa steel-works and iron rolling mills, which belong to the Zenitsa Iron Industrial Company, with a share capital of three and a half million kroners, comprise two open-hearth furnaces, each of fourteen tons capacity, a double gas puddling furnace, and three small smelting furnaces. The annual production averages about 16,000 tons of open-hearth ingots, and 12,000 tons of rolled iron.

Slovenia.—In Slovenia iron ore in deposits of no great extent has been mined in several districts, but very little is now obtained. They appear to have formed the basis of a considerable industry in the Middle Ages, while many mines date back to Pre-Roman times. One of the more important districts is the neighbourhood of Assling and Jauerburg in the Upper Save valley, 32 miles north-west of Ljubljana (or Laibach). In this district irregular masses of chalybite occur over a considerable area in the Triassic limestones. They have been mined on a small scale here, and also at Belshitsa and Lepene, where they frequently carry small quantities of galena, while at Save near Assling, the iron ore is often accompanied by both lead and zinc ores.

Similar occurrences have also been mined lower down the Save valley in the neighbourhood of Kropp, Kranj, and Radovljitsa, 15 miles north of Ljubljana. Here the workings have been carried to a depth of 100 yards, but explorations in places show oolitic iron ore replacing Triassic limestones to a depth of 250 yards. A formerly important centre was Hof in southern Slovenia, 28 miles south-east of Ljubljana. Here pisolitic iron ores occur in very irregular masses in the Triassic limestones. The chief mining centres were Seisenburg, Weixelburg, Sittich, and Ruppertshof.

In eastern Slovenia similar occurrences have been worked at Nassenfuss, Jablanza, Thurmanhart, and Treffen in the Johannestal district, 35 miles east of Ljubljana. The ironstone mine of Nassenfuss appears to be the last one worked in Slovenia, and in the year prior to the outbreak of the European War produced 1,000 tons of red iron ore.

Iron ore occurs in Slovenia in Carboniferous rocks in two areas. The more important is that of Gonobits, 11 miles north-east of Celje, where chalybite and limonite occur in irregular masses in sandstones and shales.



The Mining Colony, Majdanpek, Serbia.

Aerial Ropeway from Majdanpek to Milanovats.

They have also been mined to a small extent at Slemen, Seitz, Sallach, and Schelesmo. A small deposit of rich limonite, with a compact and fibrous structure, has been worked at Preszka, to the east of Litija, and was formerly smelted locally.

DALMATIA AND MONTENEGRO.—There are no important deposits of iron ore in Dalmatia. One of the chief appears to be a bedded iron ore in the neighbourhood of Sibenik (or Sebenico) and Kamenar. Hematite occurs in the Trias at Ivine Vodice, to the east of Zadar (or Zara). A little to the north of this locality iron ore also occurs in the Lias formation at Velka Rovina. In the Upper Trias iron ore of no great extent occurs in the neighbourhood of Dosnitsa. Ten years ago red hematite ore containing 58% iron, 2% silica, and 0·29% phosphorus, was being mined in the Cretaceous formation at Kotlenitse, near Spljet (or Spalato). The annual production for five years averaged 500 tons.

In Montenegro beds of brown iron ore hitherto unworked occur in the neighbourhood of Piperska, to the north of Podgoritsa. Others, the extent of which is as yet unknown, occur at Sozina, in the neighbourhood of Bar (or Antivari), on the Montenegrin coast.

CROATIA AND SLAVONIA.—The only area of importance in these provinces occurs in the western districts, in the Velebit mountains and close to the Bosnian and Dalmatian provincial boundaries. Some small blast-furnaces were erected here prior to the war by an Austrian mining company, but the total annual output did not exceed 1,000 tons. Another Croatian locality is Topusko, 25 miles south-west of Sziszek. The ore here consists of brown iron ore, with an iron content ranging from 37 to 40%, and it occurs in the Trias. Limonites containing 30 to 35% of iron have also been mined in the neighbourhood of Gospits, 62 miles south-east of Fiume. There are several places in the Velebit mountains where both rich hematites and brown iron ores occur, but their exact extent is as yet unknown.

For many years iron ore has been mined and smelted on a small scale at Breslinats, 50 miles south of Zagreb, in southern Croatia. In the nineteenth century it appears to have been a centre of considerable importance, and in addition to red and brown iron ore, copper pyrites and silver-bearing galena were mined here formerly. A furnace specially equipped for the employment of charcoal fuel was erected, and, using a cold-air blast, an iron of reputed high quality was produced. These workings are at present leased to a Belgian mining company.

Smaller and less known deposits of iron ore occur at Poszega and Pleternitsa, 18 miles north-west of Brod, and at Podvinj and Sibinj, 6 miles west of Brod in Slavonia. Brown iron ore also occurs in the Triassic formation in Slavonia at Sirats near Daruvar, 22 miles north of Novska.

An old Croatian mining centre is Samobar, about 12 miles west of Zagreb, the principal town. Here siderites occurring in the Triassic sandstones and shales have been worked intermittently for many years. Another small deposit of brown iron ore occurs at Gjurmanets, in the neighbourhood of Krapina, an important brown-coal mining centre, 25 miles north of Zagreb.

SERBIA.—With the exception of the brown iron ore mined at Majdanpek in north-eastern Serbia, the more important deposits occur in the south and south-eastern districts. They here occur in the crystalline schists, traversed by eruptive rocks, which are probably responsible for the deposition of the minerals. Whether the iron-ore deposits of Serbia are in sufficient quantity to make them anything but of local importance is at present unknown.

The most important district appears to be in the Kapaonik mountains. The ore here consists principally of magnetite in association with crystalline schists and gneisses, and occurs along a north-and-south belt extending from the neighbourhood of Kraljevo southwards to Raska over a distance of more than 25 miles.

Magnetite also occurs in considerable quantity in association with the extensive basic igneous masses of the Zlatibor mountains, notably at Mokra Gora, in the Jablonitsa valley, 20 miles south-west of Uzitse in western Serbia, and at Mataruge, 6 miles south-west of Kraljevo.

Limonite has also been mined at Majdanpek in eastern Serbia, where it occurs fairly abundantly as an alteration product of extensive mineral veins. The largest deposit is at Kretschana, and has been estimated to contain over two million tons of brown iron ore. The whole of the Majdanpek iron ores, however, contain a good deal of copper, which renders smelting in the blast-furnace a matter of some difficulty. An old furnace dating from the middle of the last century is still in existence at Majdanpek, and has been used within recent years.

The iron ores of Majdanpek were mined somewhat extensively by the former Austrian Government during the temporary occupation of the district in the war. It was forwarded a distance of 12 miles to the port of Milanovats on the River Danube by the extensive aerial ropeway system installed over the mountainous country between Majdanpek and Milanovats. Thence it was transported by rail to blast-furnaces at Resicza Banya in the Banat. In 1917 about 700 tons of iron ore were being sent away daily.

At Rudna Glava, 9 miles south-east of Majdanpek, iron ore has been mined in the past. The ore-body occurs at the contact of the granite and the crystalline schists. In addition to limonite and magnetite, copper ore was also obtained.

In north-eastern Serbia at Rupusiste, two miles west of Brza Palanka, a deposit of magnetite occurs in the crystalline schists. Its actual extent is unknown. Iron ores, with small quantities of manganese, also occur in association with crystalline limestones in the Venchac mountains in the neighbourhood of Topola. Similar deposits occur to the south of Arangelovats, and at Guberevats, 18 miles south of Belgrade in northern Serbia.

An important but little known deposit of iron ore, stated to extend over an area of some 12 square miles, occurs in the Vlasina valley in southern Serbia, 18 miles east of Leskovats, and not far from the Bulgarian frontier. The ore consists mainly of magnetite and its alteration products, and was formerly mined in a primitive manner in several places. The principal localities are Massuritsa, Gavranitsa, Gare, Rupulje, Jabukovats, and Lebeta. Iron ores also occur at Korbeovats, close to the former southern frontier of Serbia, and were formerly mined with lead and copper ores.

Serbian Macedonia. — In Serbian Macedonia, iron ore was somewhat extensively mined during the late war at the Babuna mines by the Austrians. These mines, situated between the Veles and Prilep, are stated to be an extensive brown iron-ore deposit, but little is known about their actual resources. Red iron ores occurring near the Bulgarian frontier in the Osogov Mountains, to the south and west of Kriva Palanka, were formerly raised on a small scale, but little is known of their actual extent or importance. The ore, which occurs on the right bank of the Kriva Rieka, 5 miles west of Kriva Palanka, consists of masses of magnetic iron ore in talcose schists having a general strike north-east and south-west. The schists are much altered, being stained yellowish-brown by the abundant iron oxides. Magnetite, in large well-formed octahedra, is abundant in the mountain streams. Fifty years ago these ores were being mined and smelted on the spot in a very primitive fashion, with the aid of wood fuel.

Magnetite deposits occur at Sredorek and Sracin in the same district. Siderite also occurs in some abundance at Dobrovo to the immediate south of Kratovo in Macedonia. These were mined somewhat extensively in the Middle Ages during the Turkish occupation, and many scattered dumps of slag bear witness to these former activities. The industry was quite local in importance, and very primitive methods of smelting were employed.

BOOK REVIEWS

The Metallurgy of the Common Metals. By Leonard S. Austin. Fifth Edition, revised and enlarged. Cloth, octavo, 616 pages, illustrated. Price, 42s. New York: John Wiley & Sons; London: Chapman & Hall.

The first edition of this well-known book appeared in 1907, and received a considerable amount of attention, because it dealt in a convenient manner with practical methods for the extraction and refining of gold, silver, iron, copper, lead, and zinc. Other editions of the work quickly followed in 1909, 1911, and 1913, during the preparation of which the author took advantage of the opportunities offered for eliminating errors, re-writing certain sections, and adding details of new processes introduced. In the first edition, the metallurgy of iron was treated only to the point at which pig iron is produced, and in the second edition the making of wrought iron and steel was added to the portion devoted to refining. In each of the previous editions cyanidation received special attention owing to the advances made in the processes involved.

The present edition is a great improvement on its predecessors, and shows evidence of having been largely rewritten. The book is essentially American, and will be useful, as it supplies, in a convenient form, details of modern American metallurgical practice. Part I deals with introductory matters, including ores and metals, fuels, refractories, furnaces, etc. Parts II to VII deal separately with the metals given above. Part VIII deals with plant and equipment and their cost, and Part IX with the business of metallurgy, including such subjects as the general economic situation, organization, and operation and profits.

Much of the matter, especially that relating to the smelting of silver-lead and copper ores, has been obtained as a result of the author's own experience, and it is easy to detect the subjects in which the author has had less experience by the lack of important details and by the presence of minor inaccuracies.

The book is illustrated by over 300 figures, many of which could have been dispensed with without detracting from its value. Considerable carelessness has been shown in the revision of the proofs, as some twenty-two mistakes have been made in reference to figure numbers. The large number of very short chapters, containing two to four pages only, seems to be an unnecessary and undesirable feature of the book; the chapter, for instance, of three pages on concentration is very disappointing.

The author has given a large amount of information not readily obtained elsewhere, but the book appears to suffer from lack of balance. The best portions are those devoted to roasting, to the slime treatment of gold ores, and to the smelting and hydro-metallurgy of copper ores.

A chapter on typical gold-mill practice contains much useful matter, indicating variations met with in actual practice, and similar information is given regarding silver mill practice.

The book should undoubtedly find a place in every metallurgical library of any size.

C. O. BANNISTER.

Oilfield Practice. By DORSEY HAGER. Limp cloth, octavo, 310 pages, illustrated. Price 18s. New York and London: McGraw-Hill Book Company.

Those who have read the author's *Practical Oil Geology* will remember the concise manner in which he handles a highly ramified subject, and the clearness of diction which makes that book such good reading, apart from its educational value. It is not surprising to find, therefore, that this little volume presents both these characteristics, and, considering the nature of the subject dealt with, this at the outset is a decided point in its favour.

Oilfield practice is to-day one of the most highly specialized forms of commercial enterprise that it is possible to conceive; the technique involved is the outcome of a gradual evolution of engineering stratagem, adapted to the peculiar nature of the problems attendant on oil-finding. It is safe to say that no two fields in the world are exactly alike, and yet methods have to be devised to meet every contingency that may arise under diverse natural conditions. It follows, therefore, that no treatment of the subject can possibly be exhaustive, and that in a book of this size only the barest outline of the facts can be presented.

The author opens the discussion with some general observations on the petroleum industry, taking cognizance of such factors as organization, scope, and life of the industry, prices of oil, future scarcity, and the chances of locating new fields; this chapter includes an excellent diagram illustrating the uses of petroleum products, a spreading tree with its main and subsidiary branches each depicting a particular commodity derived from crude petroleum. Of interest also is the author's belief that competent geological advice gives successful results for one in every five tests, as against one in three hundred for wild-catting; this, we may remark, is a distinct compliment to a much abused profession!

In the chapters on development, drilling, and production methods, a very good account is given of modern practice, and the illustrations here are excellent. We do not, however, like the curt dismissal of "sampling" in a few short paragraphs; with the advance of microscopy as an aid to the correlation of horizons from well samples, the difficulties and importance of adequate sampling are recognized by geologist and engineer alike, and we know of several fields at the present time where this factor is engaging the closest expert attention. Relying on the driller's assessment of the nature of the rock passed through by the "feel" of the tool is, in nine cases out of ten, simply courting geological disaster. Again, sampling with rotary tools is a well-nigh impossible task ; it is certainly bad enough with a cable tool, even though a bailer be used.

The book gives the first really useful account of the transportation of oil that we have seen; apart from ordinary tank-cars and tankers, questions affecting pipe-lines, their specification, construction, and use are some of the most important raised in oilfield development. The assembling and location of the pumping plant are likewise critical factors, which, together with the capacity needed, are governed by the nature of the oil, the grade, and extent of the country over which it has to be transported. Oils of high viscosity, as in certain cases in California and Burma, have to be heated in drums at the pumping stations, necessitating a smaller interval between the latter than would otherwise be desirable.

The refinery practice described by the author in Chapter 8 concerns chiefly the production of casing-head gasolene, though the principles of refining crude oil are briefly and graphically portrayed. The methods given are entirely up to date, and some, as far as we are aware, have not appeared before in any other book. A section on the elements of valuation of an oilfield and an appendix of miscellaneous tables (with an included glossary of terms used in drilling) conclude the volume.

H. B. MILNER.

☞Copies of the books, etc., mentioned under the heading "Book Reviews" can be obtained through the Technical Bookshop of *The Mining Magazine*, 724, Salisbury House, London Wall, London, E.C.2.

NEWS LETTERS

SOUTH AFRICA

February 7.

THE STRIKE.—After a month of stagnation on gold mines and collieries, and a month of empty oratory, discussion, parading, threatening, and pleading by the strikers, we now appear to be approaching a break-up in the counsels of the trade unions. Throughout the crisis the policy of the Chamber of Mines has been refreshingly consistent and firm, based on elementary facts easy of analysis by the least techincal of inquirers. The attitude of the Government, too, has been resolute and definite. The Federation, however, faced with the insuperable difficulty of combining its divergent forces into one well-diverted power, now finds itself without any clear policy or any firm and intelligent solution to put forward in alleviation of the industry's unquestioned difficulties. The Federation executive is like the headquarters of an army composed of antagonistic divisions, foreign to each other in thought and purpose. Divided economically, its divisions are (1) the silent body of men who voted against a strike or did not vote at all ; (2) the men who voted for a strike believing that, once again, a compromise in their favour would be the normal sequel, and (3) the extremists, who aim for the crushing of the Chamber, and for the nationalization of the mines. Divided politically we have (1) the Constitutionalists, (2) the Nationalists, and (3) the extreme Republicans. Such a combination cannot last. It is inconceivable. Although, as I write, there is no sign of mutual settlement, there are the surest indications of a rapid disruption of the Federation as an effective fighting force. Sabotage is the only remaining weapon.

CHAMBER OF MINES PROPAGANDA. — Recognizing the extreme importance of gaining the support of public opinion, without which no permanent settlement in the strike can be effected, the Chamber of Mines has been remarkably active in its propaganda throughout the Union of South Africa. The Chamber cannot, normally, lay claim to any great measure of confidence or esteem in the country. Its first statements were read critically, as the pleadings of one of the accused, rather than as expert testimony.

Some of the Chamber's published data are instructively interesting as an analysis of the gold industry. The statement that, in December, 21,000 white persons on the Rand drew £847,000 in salaries and wages recalls to mind the goose with the golden eggs. Figures indicating the weight of the industry's direct contributions to the National treasury, the effects of a fall in price of gold to parity, the proportions of mine revenue remaining in South Africa and going oversea, all the figures published are giving the general public a clearer conception of matters at stake, and will give greater weight to public opinion when the strike issues are finally a basis for party warfare in Parliament.

DOOMED MINES.—The weightiest argument advanced, proving the urgency of the drastic reorganization of work and conditions proposed for a reduction in costs, always appears in the list of "doomed" mines, mines which could not pay, at present costs, with gold at par. The Chamber's list comprises twenty-one mines, whose working costs exceeded £1,000,000 in December alone.

Iron and Steel Works.—The annual meeting of the Union Steel Corporation, held in Johannesburg on January 27, covered a period which marked the end of the prosperity, first due to a war-protected market, and then to the boom prices prevailing for two or three years after the war. The progress of this company proves a good criterion of the South African iron industry as a whole. With works at Vereeniging for the production of shoes, dies, nails, tube-mill bars, reinforcing rods, rounds, flats, and channels, the Lewis and Marks enterprise has been an important factor in the development of the industry to its present stage. Now, before it has been possible to advance to the bigger scheme of production from native ores, the company is faced with difficult times, momentarily owing to the miners' strike and later to the severe competition of Continental firms. South African iron producers will not only have to face the competition of the good organization and wide development of the producers of abroad, but of the lower wages and greater efficiency of the workers paid in marks and francs. The Prime Minister has always been one of the first to recognize the urgency of fostering new industries, but the crisis on the Rand, and the utmost urgency of enabling the languishing gold industry to lower its store costs under all heads, places abnormal difficulties in the way of protective policies.

Transvaal Coal Resources.—Dr. Mellor, consulting geologist to the Central Mining and Investment Corporation, has published some clear-cut facts in a paper on his exploratory work on the Transvaal coal measures. One hears so much of "vast potentialities" that Dr. Mellor's facts are refreshing. Briefly, he estimates 1,000 million tons of cheaply workable coal in the Witbank area, east of the Rand. Probable gold-mining and railway requirements need not be considered to hold a lien on these resources of good export coal. Export and bunker trade is penalized, in respect of this area, by poor railway facilities to Delagoa Bay, and inadequate handling arrangements at the port. Certainly the South African coal trade will not suffer for lack of a good product, but it will remain for our present Transvaal and Natal collieries to lay the foundations of a healthy export trade, with normal competition abroad and mining conditions reorganized after the strike, before the scheme of a special coal-line to the coast on the extreme north of Natal, put forward by Dr. Mellor, can be more than a theme for an encouraging discussion. It is to be hoped that the commercial aspect of foreign trade possibilities will now be dealt with from the viewpoint of the Coal Owners' Association, so that it can be understood clearly in what respect the Government may be expected to assist in the realization of this latest asset.

Klerksdorp.—The history of the Klerksdorp mining district has been so full of failure and disappointment that the enterprise of the tributing party, now leasing the Afrikander Proprietary, may carry wide significance. The mine has been taken over by a combination of exceptionally experienced Rand mining engineers, who have brought to this district a constructive force unknown for many years. The Afrikander will benefit by having an effective management and control on the spot, able to ensure local economy in detailed working and also to direct and push through a consistent policy of production and exploration. With a fall in commodity prices and a sounder industrial situation throughout the country after the strike, we may see further instances of outside mining enterprise. But companies owning "unpayable mines" or prospects, and miners and mechanics seeking work must bear in mind that success can be attained only by the skill and courage of the technical men in charge. The Government, too, must give every assistance to new mining enterprises, for the miner who produces one ounce of gold from a new source does more good to the country than the favoured farmer who adds five pounds' worth of mealies or wool or wine to a glutted market.

TORONTO

February 8.

Porcupine.—The most important question affecting the future of this camp is the obtaining of a considerably greater supply of electric power than is now available. The principal producing companies are anxious to enlarge their equipment and increase their output, but these projects are necessarily dependent upon the assurance of an adequate delivery of power. Negotiations are in progress for the purchase by the Northern Canada Power Co. from the McIntyre-

Porcupine of the right to develop power at Sturgeon Falls on the Mattagami River, capable of generating 7,000 h.p., but the transaction will not be closed until the litigation between the Power Co. and the Hollinger Consolidated, over the failure of the former to deliver power last winter according to contract, is settled. The carrying out of this project would give a great impetus to production.

The plans of the Hollinger Consolidated for expansion contemplate an increase in its milling capacity from 4,000 to 7,000 tons daily. The machinery for the enlargement has been ordered, and underground development is being carried on so as to give increased hoisting facilities. Carbonaceous ore, such as occasioned serious metallurgical difficulties at the McIntyre, has been encountered in some places, but as a process of treating it has been discovered little trouble has resulted.

The report of the Dome Mines for nine months ended December 31, 1921, shows operating profits of $694,626, as compared with $706,894 for the year preceding. Current assets were $2,290,853, compared with $1,817,994. The directors have passed by-laws authorizing the repayment of capital stock to the shareholders from time to time, and the present decrease of the capital from $5,000,000 to $4,500,000, which will be submitted to the shareholders for ratification on the 11th inst. Production has been largely increased during January, the grade of the ore treated running so high as to necessitate some changes in the treatment, the mill having been constructed to handle low-grade ore.

The Porcupine Vipond-North Thompson is preparing to resume operations in April, having been assured of a supply of power. The main shaft will be put down from its present depth of 600 ft. to the 900 ft. level. At the Porcupine Paymaster the shaft is being sunk to a depth of 400 ft., where a cross-cut will be run to a large body of quartz-porphyry which shows good gold content on the 200 ft. level. The Platt Veteran claim of 160 acres, on which diamond-drilling has indicated good gold content at depth, has been sold to a Montreal syndicate, headed by McCuaig Bros. & Co., for a price stated at $300,000.

KIRKLAND LAKE.—All the mining companies with the exception of the Kirkland Lake, which reduced wages some months ago, have announced a reduction of 50 cents per day in wages, to become effective on March 1. The Lake Shore in December produced $70,854 from the treatment of 2,004 tons of ore, the mill running 90·45% of possible time. The total production for 1921 was $494,363, being an average recovery of $22·65 from a total mill tonnage of 21,820. A supplementary report on the Teck-Hughes shows a production of approximately $45,000 during December, with profits of about $25,000. Sinking operations will be continued to a depth of about 1,000 ft. Ore reserves are estimated at close to $1,000,000, the ore containing approximately $10 per ton. The gold bars shipped in January were valued at about $72,000. The ore which has recently been treated averages about $20 per ton. The Tough Oakes is preparing to resume milling operations in April. The mill is being overhauled and some extensive changes are being made in surface equipment. Good progress is being made in the development of the recently discovered ore-body, and a large tonnage of ore of a good grade has been opened up. The Ontario Kirkland is developing two ore-shoots, each about 200 ft. in length, on the 450 and 300 ft. levels, and has also encountered a good ore-body on the 150 ft. level. The new mill is in steady operation. At the Bidgood the vein at the 400 ft. level is about 20 ft. in width, 8 ft. of which carries good commercial ore.

COBALT.—A record shipment of silver bullion was made on January 27, when 14 tons was consigned to China, via New York. The Nipissing during December mined ore of an estimated value of $251,467, of which $13,755 was cobalt, and shipped bullion from Nipissing and custom ores of an estimated net value of $204,869. Development work proved the extension of the mineralized area. Operations at the Kerr Lake have been completely suspended. Development has not been as satisfactory as was expected, and it is stated that the mine will remain closed until operating costs decline materially or the price of silver advances. The Right of Way mine has been made over to a syndicate comprising the former directors, who were also creditors, represented by E. J. Daly, of Ottawa, as trustee. It is intended to resume work. The La Rose Consolidated realized upwards of $120,000 net profits during 1921, as compared with only about $1,000 during the preceding year. The gross earnings of the Bailey custom mill for January were approximately $13,370 from the treatment of 4,456 tons of ore. At the Bailey mine several veins carrying silver have been discovered. Operations at the Silver Cliff, which is worked by the Bailey, have been satisfactory.

GOWGANDA.—The shareholders of the Trethewey have authorized the sale of the assets to a new company, known as the Castle-Trethewey Mines, Ltd., capitalized at $2,000,000. The shareholders receive 400,000 shares of the new company, and the balance of 1,600,000 are offered them for sale at 10 cents per share to raise funds for discharging liabilities and carrying on development.

LARDER LAKE.—The power-plant of the Crown Reserve at Cobalt is being transferred to the company's property at Larder Lake, where an extensive exploration and development campaign will be undertaken. A three-compartment shaft will be sunk to the 300 ft. level, where diamond-drilling indicates the occurrence of a large amount of medium-grade ore running about $6 to the ton.

VANCOUVER, B.C.

February 9.

PREMIER MINE.—Probably the most interesting event of the month was the announcement made by Dale L. Pitt, general manager for the Premier Gold Mining Company, of the probable future output of the mine. Owing to the difficulty of getting ore to tide-water before the completion of the tramway, it has been impossible to glean any definite idea of what the output of the mine was likely to be, and all the Premier mine officials refused to be drawn on the subject. Now, however, that the tramway has been in operation for about a month, Mr. Pitt has divulged the following information. One hundred tons of high-grade ore per day is being shipped on the new tramway; a little later it is planned to double that output, when a lower grade of ore will be shipped to the Granby smelter, at Anyox. In addition to the high-grade ore, 400 tons of concentrate is being shipped monthly to the Tacoma smelter. This product is obtained by treating 100 tons of ore daily in the mill. The tailing from the mill is re-ground and cyanided, and from this $40,000 to $50,000 worth of precipitate is shipped monthly to the Selby smelter, on San Francisco Bay. The tramway is 11½ miles long, of which 10 miles is in Alaska. It has 153 towers, 3 angle-stations, and 12 tension-anchors. At the discharging terminal, on the wharf at Stewart, there is bin capacity for 1,500 tons of crude ore, and storage capacity for 1,000 tons of sacked concentrate. The survey was made and the tramway built within a year, which, in an inaccessible country such as that in which the Premier is situated, is in itself a record to be proud of. The tramway was built by the Riblet Tramway Company, of Spokane, Washington.

Mr. Pitt would not give any information about the values of the various products. According to the annual report of the Minister of Mines, the ore shipped from the Premier mine in 1920 averaged 96 oz. silver and 2·85 oz. gold per ton. This at present price of silver would be equivalent to about $120 per ton. If the ore now being shipped is of the same grade it would amount to $360,000, and with the second grade, concentrate, and precipitate added the monthly output of the Premier mine cannot fall far short of three-quarters of a million dollars. This is a remarkable record for a mine, the development of the ore-body of which was started only in 1919. Recently the ore-shoot has been opened in the No. 4, or bottom level, which is 700 ft. below the outcrop. The vein is said to be as strong and as rich as in the upper workings.

TIDEWATER COPPER. — The Tidewater Copper Company has resumed operations at its Indian Chief mine, at Sidney Inlet, on Vancouver Island, and expects to be in a position to commence shipping concentrate to the Tacoma smelter within a month. The Tidewater company has been developing and equipping this mine during the past four years, and had just brought it to the producing stage and shipped 400 tons of concentrate in December of 1920, when the low price of copper combined with the high cost of wages and supplies forced a shut-down. An ore-reserve of 200,000 tons, averaging 2% of copper, or better, has been developed, and an all-flotation mill with a capacity of 300 tons of ore daily has been erected. In the run prior to the shut-down 95% of the copper content was recovered, the concentrate averaging 38% copper with low gold and silver values. The ore contains a good deal of magnetite, and it is proposed to make an attempt to save this by magnetic separation.

BRITANNIA.—The Britannia Mining & Smelting Company has let contracts for the steel work for its new mill-building. The cost of the steel will be $175,000. Having in view the destruction of the old mill by fire, the new building will be of a construction as fireproof as it is possible to make it. E. J. Donohue, general manager for the company, has resigned, and no new appointment has yet been made. The effect of the disastrous flood, in which thirty-six lives were lost, has so preyed upon Mr. Donohue that he feels a prolonged holiday necessary to prevent a breakdown.

B. C. Silver.—J. A. Bush and Grant Mahoot are reported to have sold their interest in the B. C. Silver Mines, Ltd., to the Guggenheims for $100,000. The controlling interest in this property is held by the British Canadian Silver Corporation, of London. The purchase by the Guggenheims is said to have been made on a valuation of $300,000 for the whole property. The property adjoins the Premier mine, of which the Guggenheim interests already hold a controlling interest.

Cariboo.—Present indications point to a considerable revival of placer mining in the Cariboo district during the coming season. Several United States concerns are entering the field, and a good deal of hydraulicking and dry-placer mining is likely to result, while it is rumoured that one or two small dredges will be operated.

NORTH OF ENGLAND

March 4.

The Australian Zinc Concentrates.—This question has at last been dragged into the open, after long years of Parliamentary silence ; there is now some public knowledge of the contracts made with the Australian Zinc Producers Proprietary Association, Limited, but much is still hidden. Mr. Wignall on February 9 brought up the matter on the unemployment debate in the House of Commons, and obtained a promise from the President of the Board of Trade that the question should be fully debated in the House at an early date. This subsequent debate is fully reported in Hansard, Vol. 150, Nos. 11 and 12 (1s. each).

The Government put forward a motion for the supplementary sum of £601,200 to meet the loss this year on the sale of zinc concentrates and spelter purchased from the company named, and it was proposed by Sir W. Mitchell-Thompson, who reviewed the general position of the spelter industry and its relation to the production of concentrates. The terms of this Australian contract include the purchase of 300,000 tons of concentrates and 45,000 tons of spelter annually until June 30, 1930. The purchases disclosed are as follows, less sales effected at a loss :—

	Tons.	Value in £.
1919 to March 31.........	284,153	1,221,859
1920 ,, ,, ...	113,985	490,137
1921 ,, ,, ...	35,337	151,951
Total three years to March 31, 1921	433,475	1,863,947
Stock previously held	140,183	602,787
Total	573,658	2,466,734
Purchased since March 31, 1921	213,434	913,462
Present Stock.............	786,092	3,380,196

It therefore appears that the total purchases, less sales, amount to the above figures, but there are no available data showing the actual sales, either of tonnage or value. The nett result is that these stocks exist now and the loss on the 1921–2 transaction amounts to over £600,000.

The exact terms of the contract have never been disclosed to the public, but the purchase price is £4 10s. for the first 100,000 tons each year and £4 for the next 200,000 tons. It is quite possible that the mines have the right to make up the shortage on the previous year's deliveries, in which case there would be a large margin in the next few years beyond the contract of 300,000 tons per annum.

The price now being paid is far higher than that received from the continental smelters before the war, and is sufficient to make the treatment of the enormous Australian dumps a profitable proposition. As an example the Zinc Corporation finds it possible to pay the preference dividend from this source alone.

The Government has stated that this contract has had no adverse effect on the home mining industry, either direct or indirect, and its reasons for refusing to include our home mines in the contract are as follows :—

(1) That the amount produced in the United Kingdom is only a minute fraction ; in point of fact, it was only a hundredth part of the total required for the production of spelter in this country.

(2) In consequence the ore is not to be expected to be in a form, in character, or composition as it might be ; that was always one of the great troubles which the mining industry in zinc had to contend against before the war in dealing with its contracts here.

(3) That the industry cannot afford to produce ore in this country at the present level of world prices.

(4) Because it would be in fact the payment of a concealed subsidy to these industries . . . by purchasing their products which we do not actually require.

(5) That an additional subsidy would be required.

Mr. Stanley Baldwin wound up the debate and made the following statement :—

It is quite true that the amount of subsidy required to meet the particular case to which he (General Lowther) referred would be a small amount, and I do not believe it would be a large amount if it lasted over the term of five years. If you give one subsidy you cannot resist another, and as long as you lay down the rule that you are not going to give subsidies to industries in this country, directly or indirectly, you cannot break it.

The whole case of the home mines was ably dealt with by many speakers, prominent among them being Mr. Betterton and Mr. Wignall. Their arguments were put with great force, and there was no logical answer of any sort.

Taking the points summarized above, it is admitted that the home production is small and that it cannot supply the normal requirements of the smelters ; but at the same time it must be remembered that the home capacity of the smelters is only a fraction, say 25%, of the home consumption of spelter ; the difference is one of degree, yet the smelters are being, at the present time, subsidized by the supply of their raw material at say 45% of the cost of production.

Sir W. Mitchell-Thompson's contention that the home ores are inferior to the Australian concentrates is so absurd as to require no answer in a technical paper. The committee that investigated this question reported that, on the evidence of the smelters the British ores were worth about 20s. per ton more than the flotation concentrates from Australia, and the smelters are already making inquiries from the British mine-owners as to what blende they are likely to have for mixing purposes.

The Government asserts that the mines cannot work at the present level of world prices, and claims that the price of 75s. is the economic basis of value, delivered at British ports.

In another part of Mr. Baldwin's speech he states :—

The concentrates were sold at a price which was calculated to allow them (the smelters) to make spelter without loss at the world's present price.

In fact, the present price has no relation to either cost or world's prices ; it is merely an arrangement by which the Government accomplishes a political object, which is to re-start the smelting works even at a cost to the taxpayer.

The value of zinc ore would rapidly reach an economic level if natural laws were allowed to operate, and no one knows what it is likely to be in the immediate future. It is quite clear that there would be no Australian ores, as the world value at Swansea is 75s. according to Mr. Baldwin, that is, the approximate cost of transport and expenses, and the cost of production in Australia is £4 10s. The production there is not in any way economic, and is in fact the result of a subsidy on a large scale. The figures of output published in the MAGAZINE are decidedly interesting, and include five mines in the Broken Hill area.

	Tons.
Sulphide Corporation, Feb. to Dec.......	38,267
Zinc Corporation, Feb. to Dec.	100,200
North Broken Hill, July to Dec.	7,340
Broken Hill Proprietary, Sept. to Dec. ..	19,305
British Broken Hill, Dec................	1,040
	666,152

The production in these mines was 10,640 tons in February and 20,060 tons in December. There may be additional producing mines not reporting output, but the present level is nearly up to the maximum contract figure. The Government refuses to buy the small home production on the ground that it is not actually required, but it is futile to advance this as an argument, when it continues to stimulate the "unwanted" production in Australia.

The final argument is that even if the home ore were purchased on the Australian basis plus the costs incurred in marketing here, a further subsidy would be necessary. This is an absolute mis-statement, and the mine-owners have never suggested such a course. They claim equal treatment, and if they cannot produce on either the economic value of their ores, or alternatively the price that the ore purchased in other directions costs the Government, they are prepared to face the situation without a further appeal for help.

The facts are simple and the result obvious. The zinc producer in Australia is being paid a price that shows a good profit. He has no trouble or expense in placing the product on the market. He has a certain price guaranteed for over 8 years, irrespective of the demand for the ore or the world's level of prices. He is paid cash directly his ore is produced. The smelter here is provided with this ore at about 45% of the cost, a figure evidently below the world's price, and naturally takes this rather than ore from a source where economic conditions prevail. The home miner has none of these advantages, and as a direct result is crushed out of existence unless he can find some outlet that has not been destroyed by the supply of subsidized products. If he finds a market the Government may step in and undercut him at any moment.

As to the future, the Continental smelters reduced their formula basis directly it became known that the Government was determined to clear out their stocks at any cost, and a remark by Mr. Baldwin is rather suggestive : " I would say that we have not made any sales *so far* in Germany." The Government will have to sell this ore to our late opponents either directly or through other countries, and this will completely neutralize the ostensible object with which this unfortunate arrangement was conceived.

Mr. Baldwin emphasizes the fact that at some time he will be able to sell at a profit. This may be so, and it is clear that the British taxpayer cannot for ever continue to pay an enormous subsidy to the Colonies ; but in the meantime the home industry is practically destroyed and there are few mines that have the financial resources to weather the storm.

It has been a matter of surprise to the mine-owners that the Minister of Mines took no part whatever in a debate that so vitally affected an industry under his direct supervision.

PERSONAL

P. M. Anderson has been appointed general manager for the Union Corporation group, and H. R. Mill, manager of the Modder Deep, has been appointed to succeed him as consulting engineer to the group.

H. H. W. Boyes is expected from Nigeria.

J. E. Breakell has gone to Bolivia.

Dr. J. Coggin Brown left on his return to India on February 17.

A. L. Butler is home from Nigeria.

Sir John Cadman has returned from America.

G. V. Colchester has been appointed to the Geological Survey of the Anglo-Egyptian Sudan.

James Gardiner has been elected chairman of the council of the Nigerian Chamber of Mines, in succession to the Earl of Scarbrough, who has resigned, and Oliver Wethered and Alfred W. Berry have been elected deputy-chairmen. The last-named has continuously borne a large share of the work undertaken by the Chamber, and his election to the deputy-chairmanship has been well earned.

H. W. Hardinge is here from New York.

A. J. Higgin, lecturer on metallurgy in the Melbourne University, is visiting England.

R. Underwood Jarvis has gone to Manchuria.

H. H. Jeffcott has been appointed secretary of the Institution of Civil Engineers in succession to Dr. J. H. T. Tudsbery, who recently retired after twenty-six years' service.

P. J. Lock is leaving for West Africa.

D. J. Macdonald has returned from West Africa.

J. T. Marriner is here from Pahang.

William McNeill has left for Mexico.

J. S. Negru, managing editor of *Chemical and Metallurgical Engineering*, is on a long visit to Europe. He is a graduate of Liége University.

H. C. Orford is leaving for West Africa.

David E. Roberts has been elected president of the South Wales Institute of Engineers.

James Roberts has left for Singapore.

H. J. Robertson has left for the Gold Coast.

William Russell, London manager for the Dorr Company, has returned from South Africa and the Congo.

T. Skewes Saunders is examining mines and placers in Chihuahua and Sinaloa.

Professor A. C. Seward has been elected president of the Geological Society.

S. F. Shaw has completed his examination of various mining properties in Mexico for the Compania Metalurgica Mexicana.

R. O. Simon is returning from Burma.

Alexander Young Spearman, Assoc.Inst.M.M., succeeded to the baronetcy on the death of his father, Sir Joseph L. E. Spearman, last month.

Alex. Spencer has been appointed vice-chairman of the Metropolitan-Vickers Electrical Co., Ltd., succeeding the late Sir Francis Barker in that position.

J. B. Tyrrell is here from Canada.

S. Dawson Ware has left for Northern Nigeria.

P. A. Westcott is leaving for West Africa.

Percy W. Whitehead has returned from Nigeria, and is going to South America.

E. D. Miles, well known in Charters Towers for many years past, died on March 3.

Dr. Charles Baskerville, professor of chemistry in the College of the City of New York, died early last month, at the age of 52. He was one of the most successful teachers of chemistry in America, versatile, altruistic, and inspiring.

William J. Slee died in December at Wallaroo, South Australia, at the age of 58. He did much excellent work as an expert in concentration problems at Wallaroo, and at Broken Hill. Also he installed many Hancock jigs in America.

Godfrey Davey Lucas, Senior Warden of Mines for the Federated Malay States, died on January 20, at the early age of 43. He was educated at Haileybury, and at the Royal School of Mines, taking his associateship in 1901. He joined the F.M.S. Government service as an Inspector of Mines in 1902. In due course he became Assistant Warden and subsequently Warden for Perak, and was appointed Senior Warden for the F.M.S. in July, 1920. He was a faithful, able, and upright servant of the Government, and was highly esteemed by all with whom he came in contact.

TRADE PARAGRAPHS

Low & Bonar, Ltd., of Dundee, send us their charts and tables showing the monthly prices of raw jute and hessian cloth.

Nobel Industries, Ltd., have now completed the transfer of their staff to Nobel House, Buckingham Gate, S.W. 1, and their office at 6, Cavendish Square has been closed.

The W. S. Tyler Co., of Cleveland, Ohio, send us their catalogue relating to their testing sieves. This catalogue contains also information with regard to their electric " Hum-mer " vibrating screens.

The offices of Hyatt, Limited, makers of the Hyatt roller bearings, have been removed from Thurloe Place, S.W. 7, to 56, Victoria Street, S.W. 1, the new telephone numbers being Victoria 3521 and 3522.

The Colorado Iron Works Company, of Denver, U.S.A., send us their pamphlet No. 33, which gives full particulars, with working drawings and photographs, of the Akins flotation and aeration machine.

The Westinghouse International Company, of East Pittsburgh, announce the removal of their offices in Havana, Cuba, to the Edificio Banco Nacional de Cuba, where more adequate accommodation has been secured.

Salterns, Limited, of Parkstone, Dorset, send us particulars of their improved Pelton water-wheel. These machines have a wide application, and have recently been supplied for driving mine fans. Standard sizes are suitable for any pressure up to 250 ft. head.

An article in the *Engineer* for February 17 describes a small hydro-electric installation erected by Boving & Co., Ltd., of 56, Kingsway, London, W.C. 2, at Walkerburn, Peeblesshire. This is an excellent example of the type of installation often recommended in our columns for mining purposes.

Ropeways, Limited, of Eldon Street House, South Place, London, E.C. 2, inform us, in reference to recent press notices of the Dorada Railway (Ropeway Extension) Co., Ltd., that this ropeway was constructed on their well-known mono-cable system to the patented designs of their late managing director, J. Pearce Roe. This ropeway is the longest in the world, being 47 miles in length.

The Hardinge Company, of New York (London office: 11, Southampton Row, W.C. 1), send us their catalogue No. 12, which deals in considerable detail with powdered coal as fuel. The firm have recently acquired the business of the Quigley Furnace Specialities Company, and the Quigley system forms the subject of the new catalogue. They also send us a folder describing the application of the Hardinge conical mill to the grinding of phosphate rock in New Zealand.

The Consolidated Pneumatic Tool Co., Ltd., of 170, Piccadilly, London, W. 1, send us a number of pamphlets dealing with their specialities. No. 74 gives particulars of the C.P. hand-hammer rock-drill, which is made in two sizes, $2\frac{3}{8}$ in. diameter by $2\frac{3}{4}$ in. stroke, and $2\frac{5}{32}$ in. diameter and $2\frac{5}{8}$ in. stroke, respectively weighing 41 lb. and 34 lb. No. 75 describes the Little Giant BQ46 hammer drill, a one-man machine, suitable for road repairs, and for demolishing old buildings. No. 76 contains details of electric welding plants. No. 77 deals with Class N single enclosed self-oiling steam and belt driven air-compressors ; also with the portable petrol-driven air-compressor.

Thompson & Southwick, Ltd., engineers and ironfounders, of Tamworth, send us their sectional catalogue describing a number of their manufactures of interest to mining engineers. Section 1 deals with pit-head pulleys ; Section 2 with power-transmission by wire rope, containing information for consideration when installing rope drives ; Section 3 with the firm's latest improved " King " type safety detaching hook ; Section 4 with winding and hauling machinery for every purpose ; Section 5 with pumps, ram and centrifugal, electrically or belt driven ; Section 6 with the " Velox " pit-prop tapering machine ; Section 7 with blacksmith's hearths and tools, grindstones, etc. ; and Section 8 with castings of all kinds in iron, steel, brass, and other metals.

THE GENERAL ELECTRIC CO.'S WORKS AT WITTON

The General Electric Co., Ltd., of Magnet House, Kingsway, London, W.C. 2, invited representatives of the technical and financial press to an inspection of their Witton engineering works at Birmingham on February 7. The arrangements in connexion with the visit formed a typical example of the handsome and business-like methods of the firm, and the pressmen not only enjoyed themselves but acquired much valuable information during the inspection of the works. In the earlier days the company was noted particularly for the lighter departments of electrical engineering, but since the establishment of the Witton works it has been in a position to manufacture from start to finish the heaviest electrical machinery commercially possible at the present time ; for instance, to design and construct electrical machinery and control gear for the complete equipment of power stations, railways, ships, mines, and iron and steel works. The building of the Witton works commenced early in 1901, and as they have gradually grown, so has a thriving suburb which depends upon them for its prosperity.

The recent extensions at Witton comprise seven new buildings, namely, switchgear works, standard motor works, administrative offices, development department, moulded insulation works, enamelling and plating works, and the club house ; while the foundry, main engineering works, and small motor works have had several new bays added. From the heavy engineering point of view the work at Witton is closely linked with that at the associated Fraser & Chalmers Engineering Works at Erith. High-speed alternators and direct current generators are manufactured at Witton, and the turbines for driving these units come from Fraser & Chalmers Engineering Works. The winding, haulage, and conveyor equipments made at Erith are driven by Witton motors controlled by switch-gear produced in the new switchgear works. Another association is that with the Pirelli-General Cable Works at Southampton ; the question of cables for carrying large quantities of power at high voltage—so soon likely to be required in this country—is a most important one in modern electrical schemes.

The main engineering works at Witton are divided into four extensive bays, and all classes of electrical machines from 100 h.p. (and smaller machines, if of a special nature) are here constructed, including turbo-generators, slow-speed generators for reciprocating steam or internal combustion engine drive, rotary converters, and motors for driving many varieties of industrial plant. The most interesting bay is perhaps that devoted to turbo-alternators. At the eastern end of this bay the stator castings and rotor forgings are brought in. The G.E.C. have always made use of the solid rotor for their high-speed alternator, and the success achieved by their machines has fully justified this policy. The end of the bay is equipped with a range of specially designed machine tools for turning and milling the rotors and for boring and slotting operations on the stators, tools which are capable of dealing with parts of the largest machines required in modern practice. After the machining is completed the stator cores are built up and tightly clamped in position. Both stator and rotor now pass to the winding section, and subsequently to assembly, test, and despatch. In this bay were seen many rotors and stators in various stages of completion, some undergoing the operations referred to, others nearly ready for test. Units which attracted special attention were one for the Borough of Marylebone, and another, rather larger, intended for Bury Corporation. Others to be noted were for Guest, Keen, & Nettlefold; one for Bolckow, Vaughan & Co., and others for Darlington and Newport Corporations. The demand from the Colonies for this class of machine is increasing, three sets being built for Pretoria and three of rather greater capacity for Auckland. One of the alternators lately built was for the St. John Del Rey Mining Co., intended to be driven by water turbine. Two other bays are equipped with modern machine tools capable of dealing with heavy parts for large slow-speed generators, rotary converters, induction motors, etc., while the fourth is devoted to winding, special provision being made for impregnation, etc. The foundry attached to the main engineering works is believed to be the largest of its kind in the midlands.

Another building of great interest is the switchgear works. In one main bay switchboards are erected; starters and controller gear occupy another (these two being on one side of the stores); ironclad and heavy switchgear in general is constructed on the opposite sides of the stores, where a section is set apart for the many machine tools required. There is also a series of small shops on this side of the works, in each of which one of the various auxiliary processes—such as plating, enamelling, slate drilling, and cementing—are carried on. A fully equipped test runs across one end of the works at right angles to the bays, and the packing and despatch department adjoins. An important switchgear contract now being undertaken at Witton is for the complete equipment of a special switchgear house for the Metropolitan Railway. The main section of the contract calls for 11,000 volt gear to control one 12,000 k.v.a. alternator, five 5,000 k.v.a. alternators, 15 outgoing 300 ampere feeders, etc. The switchgear house is to be constructed in three storeys, with the bus-bar chambers on the top floor, oil switches in the middle, and instrument transformers below. All the switches are to be electrically remote controlled from special operating panels on the third floor. The high-tension gear will be in brick cubicles. The oil switches will be of the firm's type 6, which has a breaking capacity of 350,000 k.v.a.

The development department is one of the most modern ideas connected with works such as those at Witton. The G.E.C. some years ago laid the foundation of what is to-day a highly developed organization for scientific research, with a central research laboratory now being established at Wembley, near London, which undertakes the investigation of the more abstruse manufacturing problems encountered by the various G.E.C. associated factories, while to fill the gap between research and production the company has established development departments at its various works which function as a liaison in these two directions. Following out these principles, everything that is done at Witton is based on careful experiments carried out in the development department, which is situated near the northern border of the company's estate.

In conclusion note should be made of the social work carried out by the welfare department at Witton among the workers. These activities have for their home the magnificent new club house, and the playing fields which cover many acres on the eastern side of the G.E.C. estate. The club was built for the company in memory of the many who went from Witton to the Front, and did not return.

METAL MARKETS

Copper.—Despite occasional rallies, values of standard copper fell steadily during the month of February. Many factors assisted in the decline, the remarkable firmness of the sterling exchange with America being not the least, while, of course, sentiment in the United Kingdom had for a long time past been depressed by the poor state of trade. Furthermore, reports from the United States became decidedly less optimistic during the month, and a steady fall was also recorded on that side, electrolytic receding from 13⅝ cents to 12¾ cents. With this last supporting factor removed, it was but natural that standard values in London should suffer. The market does not present a very attractive aspect at the present time, although the recent fall in prices has discounted much that might otherwise be considered as adverse to the maintenance of prices. Demand from English consumers was not very large during the month, and Continental buying, although moderate, was interfered with by various factors, among which the German rail strike may be mentioned. The slackness of European demand contributed to no mean extent to the weakness in America, where sentiment generally is less optimistic than was the case recently. There is now little prospect of anything approaching a shortage of metal in the United States during the early part of this year, as was once anticipated in some quarters, and unless conditions improve some difficulty may be experienced in placing the fresh output of the recently reopened mines.

Average price of cash standard copper: February, 1922, £60 6s. 1d.; January, 1922, £65 4s. 9d.; February, 1921, £71 0s. 9d.; January, 1921, £71 1s. 4d.

Tin.—A further heavy fall was seen in values on the standard tin market in London during last month, and although towards the close of February some recovery took place, the loss on balance was substantial. The weakness was caused by the pessimism induced by the poor statistical position and the unsatisfactory trade outlook, considerable liquidation occurring on 'Change at times. Far from being discouraged by the lower values ruling in London, output in the Straits appeared to be maintained almost unchecked, and with generous

Daily London Metal Prices: Official Closing
Copper, Lead, Zinc, and Tin per Long Ton

Copper

	Standard Cash	Standard (3 mos.)	Electrolytic	Wire Bars	Best Selected
	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.
Feb.					
10	61 10 0 to 61 12 6	62 10 0 to 62 12 6	67 0 0 to 69 0 0	68 0 0 to 69 0 0	65 0 0 to 67 0 0
13	61 12 6 to 61 15 0	62 12 6 to 62 15 0	67 0 0 to 69 0 0	68 0 0 to 69 0 0	— —
14	61 0 0 to 61 2 6	61 17 6 to 62 0 0	67 0 0 to 69 0 0	68 0 0 to 69 0 0	65 0 0 to 67 0 0
15	60 2 6 to 60 5 0	61 2 6 to 61 5 0	66 0 0 to 68 0 0	67 0 0 to 68 0 0	— —
16	60 10 0 to 60 12 6	61 10 0 to 61 12 6	66 0 0 to 68 0 0	67 0 0 to 68 0 0	— —
17	59 17 6 to 60 0 0	60 17 6 to 61 0 0	66 0 0 to 67 10 0	67 0 0 to 67 10 0	64 0 0 to 66 0 0
20	58 0 0 to 58 2 6	59 0 0 to 59 2 6	64 10 0 to 66 10 0	65 10 0 to 66 10 0	— —
21	58 0 0 to 58 2 6	59 0 0 to 59 2 6	63 10 0 to 65 10 0	64 10 0 to 65 10 0	61 0 0 to 63 0 0
22	57 7 6 to 57 10 0	58 7 6 to 58 10 0	63 10 0 to 65 10 0	64 10 0 to 65 10 0	— —
23	57 7 6 to 57 10 0	58 7 6 to 58 10 0	63 10 0 to 65 10 0	64 10 0 to 65 10 0	— —
24	58 0 0 to 58 2 6	58 17 6 to 59 0 0	63 10 0 to 65 10 0	64 10 0 to 65 10 0	61 0 0 to 63 0 0
27	59 15 0 to 59 17 6	60 15 0 to 60 17 6	63 10 0 to 65 10 0	64 10 0 to 65 10 0	— —
28	58 15 0 to 58 17 6	59 15 0 to 59 17 6	63 10 0 to 65 10 0	64 10 0 to 65 10 0	61 0 0 to 63 0 0
Mar.					
1	58 17 6 to 59 0 0	59 17 6 to 60 0 0	63 10 0 to 65 10 0	64 10 0 to 65 10 0	— —
2	59 0 0 to 59 2 6	59 17 6 to 60 0 0	64 0 0 to 66 0 0	65 0 0 to 66 0 0	— —
3	59 5 0 to 59 7 6	60 5 0 to 60 7 6	64 10 0 to 66 10 0	65 10 0 to 66 10 0	61 10 0 to 63 10 0
6	60 0 0 to 60 2 6	60 17 6 to 61 0 0	65 0 0 to 66 10 0	65 10 0 to 66 10 0	— —
7	60 2 6 to 62 5 0	61 2 6 to 61 5 0	65 15 0 to 67 5 0	66 15 0 to 67 5 0	64 0 0 to 66 0 0
8	61 2 6 to 61 5 0	62 2 6 to 62 5 0	67 5 0 to 67 15 0	67 5 0 to 67 15 0	— —
9	60 7 6 to 60 10 0	61 7 6 to 61 10 0	67 10 0 to 68 0 0	67 10 0 to 88 0 0	—

sales being made in that quarter, it was not surprising that the market should view the position with accentuated distrust. The recovery which took place later was probably more in the nature of a reaction after the heavy fall, and to a realization of the fact that prices had dropped to a remarkably low figure, rather than to any actual improvement in either genuine demand or in market confidence. English consumers bought on a comparatively restricted scale, and Continental buyers exhibited only moderate interest. Meanwhile, America, though a fairly large buyer, purchased with caution and mainly when the market was receding. Little support, therefore, was accorded to the London market from this quarter. Batavia and China were rather reserved, offering but little, and fair stocks would appear to be available there.

Average price of cash standard tin: February, 1922, £149 19s. 6d.; January, 1922, £163 3s. 4d.; February, 1921, £166 9s. 1d.; January, 1921, £190 13s. 11d.

Lead.—At the beginning of February an easy tendency was in evidence in the London market, but later a steadier tone appeared, and although appreciable fluctuations took place, the fall appeared to have been arrested for the time being. Most of the business passing was of a speculative or professional nature, the easiness being largely due to the liquidation of stale bull accounts. Consuming demand continued restricted, although towards the end of the month some extra interest seemed to be aroused by the lower level of prices then reached. The Continent was a fairly good buyer, but took a large part of its needs from America. Supplies were on an ample scale, good quantities coming into the United Kingdom from Australia, Africa, and Burma, while the fall in the dollar permitted sales of American lead to this country. Spain has recently been featuring as only an inconsiderable seller, and it is understood that stocks are accumulating in that country.

Average price of soft pig lead: February, 1922, £20 12s. 10d.; January, 1922, £23 12s. 2d.; February, 1921, £21; January, 1921, £23 12s. 6d.

Spelter.—A downward movement at the beginning of the month of February was followed by fluctuating markets, with the result that at the close prices were very little below the opening. Business was pretty quiet during the month, and at one time sentiment was rather pessimistic in view of the rise in sterling exchange, which entailed the threat of American offers. Up to the present, however, the sales by the United States have not assumed very large proportions, and as Continental producers have continued extremely reserved as regards making fresh offers, there has been little selling pressure. In consequence, despite the quietness of consuming demand everywhere, values were fairly well maintained, and stocks in the United Kingdom continued to decrease. The outlook is rather in favour of more plentiful offers, however, as Belgian output has recently expanded considerably, and it is felt that producers in that country will find themselves forced to offer in London to meet American competition. The United States, it is known, possesses fairly large stocks and is taking steps to increase its output. Meanwhile, English smelters are again getting to work. Unless consuming demand broadens, therefore, the possibilities are in favour of an excess of supply over demand in the near future, which state of affairs would hardly permit the existence of a very firm market.

Average price of spelter: February, 1922, £24 9s. 9d.; January, 1922, £26 10s. 2d.; February, 1921, £25 5s. 5d.; January, 1921, £25 15s. 7d.

Zinc Dust.—Quotations are steady, as follow: Australian high-grade £50, American 92 to 94% £47 10s., and English 90 to 92% £45 per ton. These prices are somewhat nominal.

Antimony.—Prices are unaltered: English regulus, £34 to £37 for ordinary brands, and £35 5s. to £39 for special brands. Business in foreign material is quiet, with £24 10s. per ton quoted for home orders and somewhat less for export.

Arsenic.—The market is dull, Cornish white 99% remaining unchanged at £40 per ton, delivered London.

Prices on the London Metal Exchange.
Silver per Standard Ounce ; Gold per Fine Ounce.

Lead: Soft Foreign	Lead: English	Zinc (Spelter)	Standard Tin: Cash	Standard Tin: 3 mos.	Silver: Cash	Silver: Forward	Gold	
£ s. d. £ s. d.	£ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	d.	d.	s. d.	Feb.
20 15 0 to 20 12 6	22 0 0	24 0 0 to 24 15 0	152 15 0 to 153 0 0	154 15 0 to 155 0 0	34½	33⅞	95 1	10
21 0 0 to 20 17 6	22 5 0	24 5 0 to 25 0 0	153 2 6 to 153 7 6	155 2 6 to 155 7 6	34½	34¼	95 6	13
20 15 0 to 20 12 6	22 5 0	23 17 6 to 24 12 6	152 0 0 to 152 5 0	153 15 0 to 154 0 0	34⅜	34	95 4	14
20 10 0 to 20 7 6	21 15 0	24 0 0 to 24 10 0	149 5 0 to 149 10 0	151 0 0 to 151 5 0	34⅜	34	95 4	15
20 10 0 to 20 10 0	21 15 0	24 0 0 to 24 12 6	149 0 0 to 149 5 0	151 0 0 to 151 5 0	33⅞	33⅝	95 7	16
20 2 6 to 20 2 6	21 10 0	24 0 0 to 24 10 0	148 5 0 to 148 10 0	150 5 0 to 150 10 0	34⅛	33⅞	95 7	17
19 17 6 to 19 17 6	21 10 0	24 0 0 to 24 10 0	144 0 0 to 144 2 6	146 0 0 to 146 5 0	33⅜	33⅛	95 4	20
19 10 0 to 19 10 0	21 10 0	24 0 0 to 24 7 6	140 0 0 to 140 5 0	141 17 6 to 142 2 6	33⅝	33⅛	94 9	21
19 12 6 to 19 12 6	21 10 0	24 0 0 to 24 7 6	140 2 6 to 140 7 6	142 2 6 to 142 7 6	33⅛	32⅞	93 10	22
20 2 6 to 20 2 6	21 10 0	24 7 6 to 24 17 6	142 0 0 to 142 5 0	144 0 0 to 144 5 0	33	32¾	93 9	23
20 10 0 to 20 10 0	21 15 0	24 7 6 to 24 15 0	144 0 0 to 144 5 0	146 0 0 to 146 5 0	32⅝	32⅜	93 10	24
20 12 6 to 20 12 6	21 15 0	24 10 0 to 24 17 6	147 10 0 to 148 0 0	149 10 0 to 149 15 0	32½	32¼	94 7	27
20 10 0 to 20 7 6	21 15 0	24 10 0 to 25 0 0	145 0 0 to 145 5 0	146 15 0 to 147 0 0	32⅛	31¾	93 6	28
								Mar.
20 12 6 to 20 10 0	21 15 0	24 10 0 to 25 0 0	141 0 0 to 141 5 0	143 0 0 to 143 5 0	32⅜	31⅝	93 3	1
20 10 0 to 20 7 6	21 15 0	24 15 0 to 25 2 6	141 15 0 to 142 0 0	143 15 0 to 144 0 0	32⅛	31⅝	93 6	2
20 17 6 to 20 12 6	22 5 0	24 17 6 to 25 5 0	143 7 6 to 143 10 0	145 7 6 to 145 10 0	32⅞	32⅝	93 6	3
20 15 0 to 20 12 6	22 5 0	25 2 6 to 25 7 6	144 15 0 to 145 0 0	146 17 6 to 147 0 0	32⅝	32¼	94 6	6
20 12 6 to 20 10 0	22 0 0	25 7 6 to 25 10 0	142 0 0 to 142 5 0	144 0 0 to 144 5 0	33⅛	32¾	94 6	7
20 15 0 to 20 12 6	22 5 0	25 17 6 to 25 17 6	142 15 0 to 143 0 0	144 15 0 to 145 0 0	32⅞	32⅝	95 0	8
20 15 0 to 20 12 6	22 5 0	25 15 0 to 25 15 0	142 0 0 to 142 5 0	144 0 0 to 144 5 0	33¼	33	95 0	9

Bismuth.—Sellers continue to quote 9s. per lb.

Cadmium.—The price has eased slightly to 5s. 6d. to 5s. 9d. per lb.

Aluminium.—Home producers quote £120 for home and £125 for export, but these figures are nominal. Continental metal is on offer below £90 per ton f.o.b.

Nickel.—Demand is practically stagnant. Home makers ask £175 for both home and export, while foreign metal, although obtainable at considerably less, is difficult of sale.

Cobalt Metal.—Unchanged at 14s. per lb.

Cobalt Oxides.—The market is quiet, with black oxide priced at 10s. 9d. and grey at 12s. per lb.

Platinum.—Manufactured metal is quoted at £19 and raw at £17 per oz.

Palladium.—Prices are rather easier, sheets and wire now being about £16, and raw about £12 10s. per oz.

Quicksilver.—Business has been quiet, and the quotation has weakened to £10 15s. to £11 per bottle.

Selenium.—The price of powder is steady at 9s. per lb.

Tellurium.—Sellers continue to ask 60s. per lb.

Sulphate of Copper.—A further fall has occurred, £27 10s. per ton being now quoted for both home and export business.

Manganese Ore.—The present quotation for Indian material is 1s. 1d. to 1s. 1¼d. per unit c.i.f. Caucasian is called about 1s. 1½d. to 1s. 2½d.

Tungsten Ore.—Business is dull, and the price of 65% WO_3 nominal at 9s. 6d. to 10s. per unit c.i.f.

Molybdenite.—The market is quiet, with 85% priced at 27s. 6d. per unit c.i.f.

Chrome Ore.—Values are somewhat harder, Indian material being now quoted at about £4 5s. per unit c.i.f.

Silver.—From 35⅛d. on February 1 the price of spot bars receded to 34⅛d. on the 8th, owing to selling by India and China. India then bought, and the quotation recovered to 34½d. on the 13th, only to dip to 33⅞d. on the 16th, under the stress of American and Continental liquidation. Subsequently considerable Chinese sales of forward silver were a feature, and although a little Indian support carried the price to 34⅛d. on the 17th, it fell to 33¼d. on the following day. After a reaction to 33⅝d. on the 21st, the quotation fell away steadily, closing on the 28th at 32⅛d.

Graphite.—Madagascar, 80 to 90%, fell heavily during the month from £18 to £11 per ton c.i.f., owing to quiet demand and the anxiety of some holders to liquidate. Later an improvement occurred, and we call the price £16.

Iron and Steel.—There has been quite a marked improvement in the demand for pig iron, and while the home trade has shown a considerable interest, shipments have been made to Germany and also to Italy. It was hoped that at last trade was beginning to turn, and makers were looking for the time when they could start up a few more furnaces, thereby reducing standing charges, but complications have arisen, in the form of increased prices for fuel owing to a strong demand from the Continent ; and pig iron producers are therefore chary of increasing their output until they are certain as to whether they will be obliged to put up their prices or not. In the meanwhile quotations for Cleveland material are quite firm, with No. 3 G.M.B. quoted at 90s. for home and export. At the beginning of the month East Coast mixed numbers were quoted at 92s. 6d., but with a good demand and dearer fuel, prices have advanced to 97s. 6d. Wales has shown most interest among home consumers, while export shipments have been made to one or two Continental countries. In the finished iron and steel trades, works that were taking low prices for export seem to have got a fair amount of orders in hand, and are not now such keen sellers at cut prices. The big makers are rigidly adhering to their quotations, and the near future is uncertain owing to the increase in raw materials. Continental business with this country has been exceedingly slow, in spite of a weakening tendency on that side, the main hindrance still being the long deliveries offered.

STATISTICS

PRODUCTION OF GOLD IN THE TRANSVAAL.

	Rand	Elsewhere	Total	Price of
	Oz.	Oz.	Oz.	Gold per oz.
				s. d.
Total, 1920	7,949,038	204,587	8,153,625	—
January, 1921	637,425	14,168	651,593	105 0
February	543,767	14,370	588,137	103 9
March	656,572	14,551	671,123	103 9
April	665,309	16,073	681,382	103 9
May	671,750	16,026	687,776	103 9
June	663,383	15,107	678,490	107 6
July	673,475	16,080	689,555	112 6
August	695,230	16,296	711,526	111 6
September	674,157	16,939	691,096	110 0
October	690,348	17,477	707,825	103 0
November	688,183	16,053	704,236	102 0
December	664,935	16,912	681,847	95 6
Total, 1921	7,924,534	190,052	8,114,586	—

NATIVES EMPLOYED IN THE TRANSVAAL MINES.

	Gold mines	Coal mines	Diamond mines	Total
December 31, 1920	159,671	14,263	3,340	176,522
January 31, 1921	165,287	14,541	3,319	183,147
February 28	171,518	14,697	1,612	187,827
March 31	174,364	14,906	1,364	190,634
April 30	172,826	14,908	1,316	189,050
May 31	170,595	14,510	1,302	186,407
June 30	168,152	14,704	1,317	184,173
July 31	166,999	14,688	1,246	182,933
August 31	169,008	14,446	1,207	184,661
September 30	171,912	14,244	1,219	187,375
October 31	175,331	13,936	1,223	190,490
November 30	176,410	13,465	1,217	191,092
December 31	177,836	13,280	1,224	192,340

COST AND PROFIT ON THE RAND.

Compiled from official statistics published by the Transvaal Chamber of Mines. Figures for yield include premium.

	Tons milled	Yield per ton	Work'g cost per ton	Work'g profit per ton	Total working profit
		s. d.	s. d.	s. d.	£
January, 1921	1,805,235	35 0	26 3	8 9	829,436
February	1,575,320	35 6	28 6	7 0	550,974
March	1,958,730	34 5	26 1	8 4	813,636
April	1,991,815	34 5	25 10	8 7	854,533
May	1,955,357	35 3	26 2	9 1	889,520
June	1,966,349	35 10	25 10	10 0	979,769
July	2,010,236	37 2	25 7	11 7	1,163,565
August	2,050,722	37 3	25 4	11 11	1,226,282
September	1,997,086	36 8	25 2	11 6	1,151,127
October	2,041,581	34 4	24 9	9 7	981,597
November	2,007,617	34 6	24 9	9 9	978,931
December	1,954,057	31 11	24 11	7 0	683,565

PRODUCTION OF GOLD IN RHODESIA.

	1920	1921	1922
	oz.	oz.	£
January	43,428	46,956	53,541
February	44,237	40,816	
March	45,779	31,995	
April	47,000	47,858	
May	46,266	48,744	
June	45,054	49,466	
July	46,208	51,564	
August	48,740	53,200	
September	45,471	52,436	
October	47,343	53,424	
November	46,782	53,098	
December	46,190	55,968	—
Total	552,498	591,525	53,541

TRANSVAAL GOLD OUTPUTS.

	December		January	
	Treated Tons	Yield Oz.	Treated Tons	Yield Oz.
Aurora West	10,550	£13,711*	—	—
Brakpan	53,000	22,594	—	—
City Deep	82,500	34,288	—	—
Cons. Langlaagte	43,000	£60,624*	—	—
Cons. Main Reef	49,800	17,788	—	—
Crown Mines	152,000	44,118	—	—
D'rb'nRoodepoortDeep	26,000	8,699	—	—
East Rand P.M.	129,000	32,371	—	—
Ferreira Deep	18,309	7,148	—	—
Geduld	46,000	17,065	—	—
Geldenhuis Deep	50,662	13,331	—	—
Glynn's Lydenburg	3,920	£7,038‡	4,030	£7,169§
Goch	15,700	£18,302*	—	—
Government G.M. Areas	141,000	£286,488*	—	—
Kleinfontein	48,200	13,393	—	—
Knight Central	30,000	6,883	—	—
Langlaagte Estate	45,000	£64,702*	—	—
Luipaard's Vlei	20,715	£20,004*	—	—
Meyer & Charlton	14,500	£40,505*	—	—
Modderfontein, New	105,000	48,441	—	—
Modderfontein B	56,000	28,640	—	—
Modderfontein Deep	41,600	22,997	—	—
Modderfontein East	24,200	10,499	—	—
New Unified	11,900	£12,151*	—	—
Nourse	45,800	14,858	—	—
Primrose	22,200	£24,459*	—	—
Randfontein Central	118,500	£161,339*	—	—
Robinson	38,600	8,772	—	—
Robinson Deep	62,000	18,897	—	—
Roodepoort United	17,100	£17,181*	—	—
Rose Deep	52,600	13,109	—	—
Simmer & Jack	59,200	14,203	—	—
Springs	42,000	18,813	—	—
Sub-Nigel	10,700	6,511	—	—
Transvaal G.M. Estates	16,690	£22,876‡	16,230	£25,053§
Van Ryn	32,750	£46,308*	—	—
Van Ryn Deep	54,000	£132,174*	—	—
Village Deep	48,000	15,422	—	—
West Rand Consolidated	33,000	£44,071*	—	—
Witw'tersr'nd (Knights)	45,200	£53,187*	—	—
Witwatersrand Deep	35,380	10,393	—	—
Wolhuter	32,500	7,757	—	—

* Gold at £4 15s. 6d. per oz. ‡ £4 13s. 6d. per oz. § £4 13s. 6d. per oz.

RHODESIAN GOLD OUTPUTS.

	December.		January.	
	Tons	Oz.	Tons	Oz.
Cam & Motor	15,000	5,172	14,661	5,241
Falcon	15,501	2,913‖	16,088	3,001*
Gaika	4,158	1,492	4,258	1,507
Globe & Phœnix	6,102	7,142	6,131	6,657
Jumbo	1,350	471	1,300	459
London & Rhodesian	3,932	£3,847	3,695	£3,585
Lonely Reef	5,100	4,849	5,630	5,193
Planet-Arcturus	5,930	2,604	5,930	2,828
Rezende	6,000	2,853	6,000	2,839
Rhodesia G.M. & I.	227	304	260	296
Shamva	59,100	£38,617§	59,900	£38,582‡
Transvaal & Rhodesian	1,500	£4,800†	1,600	1,121

* Also 291 tons copper. † At par. ‖ Also 275 tons copper.
§ Gold at £4 16s. per oz. ‡ Gold at £4 13s. 9d. per oz.

WEST AFRICAN GOLD OUTPUTS.

	December		January	
	Tons	Oz.	Tons	Oz.
Abbontiakoon	7,150	£14,132*	7,200	£13,361*
Abosso	5,800	2,348	6,143	2,487
Ashanti Goldfields	7,524	8,358	7,500	8,121
Obbuassi	550	£2,445†	574	742
Prestea Block A	7,547	£11,123*	7,435	£13,777*
Taquah	3,190	2,030	3,170	2,004

* At par. † Including premium.

West Australian Gold Statistics.—Par Values.

	Reported for Export Oz.	Delivered to Mint Oz.	Total Oz.	Par Value £
May, 1921	474	47,638	51,503	217,495
June	153	28,194	28,347	120,410
July	1,641	44,917	46,558	197,774
August	110	51,731	51,841	220,205
September	380	50,728	51,108	217,092
October	1,910	51,286	53,196	225,959
November	156	46,429	46,585	197,879
December	451	53,348	53,799	228,522
January, 1922	329	37,851	38,180	162,177
February	926	41,194	42,120	178,913

Australian Gold Outputs.

	West Australia	Victoria	Queensland	New South Wales
1921	oz.	oz.	oz.	1922 £
January	51,458	4,587	4,582	11,855
February	27,557	10,940	9,046	—
March	47,886	12,383	6,690	—
April	47,273	5,954	2,591	—
May	48,113	10,280	2,077	—
June	28,347	10,431	1,602	—
July	46,558	5,528	1,531	—
August	51,842	8,941	1,413	—
September	51,108	9,113	2,601	—
October	53,197	8,496	1,595	—
November	46,586	7,766	1,356	—
December	53,803	10,752	3,657	—
Total	553,730	104,512	38,741	11,855

Australasian Gold Outputs.

	December		January	
	Tons	Value £	Tons	Value £
Associated G.M. (W.A.)	4,733	7,067‖	4,034	5,718‖
Blackwater (N.Z.)	2,533	4,981*	2,909	5,637*
Gold'n Horseshoe (W.A)	7,248	4,155‡	7,788	4,233‡
Grt Boulder Pro. (W.A.)	6,425	19,275‖	7,980	23,940‖
Ivanhoe (W.A.)	11,385	4,094‡	10,055	4,446‡
Lake View & Star (W.A.)	4,995	12,812‖	5,212	8,628‖
Oroya Links (W.A.)	1,163	8,432‖†	1,032	6,004‖†
South Kalgurli (W.A.)	5,740	9,740‖	5,144	9,932‖
Waihi (N.Z.)	14,547	3,844‡ 50,571§	7,674	2,261‡ 10,441§
,, Grand Junc'n (N.Z.)	5,150	1,529‡ 4,898§	—	—

* Including premium; † Including royalties; ‡ Oz. gold § Oz. silver; ‖ At par.

Miscellaneous Gold and Silver Outputs.

	December.		January	
	Tons	Value £	Tons	Value £
Brit. Plat. & Gold (C'lbia)	—	—	—	285*p*
El Oro (Mexico)	32,000	167,000†	32,300	186,130†
Esperanza (Mexico)	—	899*e*	—	—
Frontino & Bolivia (C'lbia)	2,300	7,998	2,010	8,688
Keeley Silver (Canada)	—	37,000*s*	—	51,000*s*
Mexico El Oro (Mexico)	13,130	180,100†	13,000	188,200†
Mining Corp. of Canada	—	—	—	—
Oriental Cons. (Korea)	16,908	102,000†	—	71,640†
Ouro Preto (Brazil)	7,200	2,600‖	7,600	2,738‖
Plym'th Cons. (Calif'rnia	8,400	10,164*	8,500	8,621*
St. John del Rey (Brazil)	—	45,000*	—	45,000*
Santa Gertrudis (Mexico)	34,077	12,624‡	32,628	63,541‡
Tomboy (Colorado)	18,000	79,000†	17,700	78,000†

* At par. † U.S. Dollars. ‡ Profit, gold and silver. ‖ Oz. gold. *p* Oz. platinum and gold. *s* Oz. silver. *e* Profit in dollars.

Nechi (Colombia): 30 days to February 1, $14,374 from 234,915 cu. yd.

Pato (Colombia): 23 days to February 10, $17,807 from 156,924 cu. yd.

Indian Gold Outputs.

	December		January	
	Tons Treated	Fine Ounces	Tons Treated	Fine Ounces
Balaghat	3,300	2,666	3,250	2,446
Champion Reef	11,697	4,907	11,894	4,939
Mysore	17,599	10,514	17,565	10,525
North Anantapur	550	642	550	603
Nundydroog	9,048	5,357	9,521	5,039
Ooregum	12,000	8,492	12,900	8,483

Production of Gold in India.

	1918	1919	1920	1921	1922
	Oz.	Oz.	Oz.	Oz.	Oz.
January	41,420	38,184	39,073	34,028	32,035
February	40,787	36,384	38,872	32,529	—
March	41,719	38,317	38,760	32,576	—
April	41,504	38,248	37,307	32,363	—
May	40,889	38,608	38,191	32,656	—
June	41,264	38,359	37,864	32,207	—
July	40,229	38,549	37,129	32,278	—
August	40,496	37,850	37,375	32,498	—
September	40,088	36,813	35,497	32,642	—
October	39,472	37,138	35,023	32,186	—
November	36,984	39,628	34,522	32,293	—
December	40,149	42,643	34,919	32,293	—
Total	485,236	461,171	444,532	390,848	32,035

Base Metal Outputs.

		Dec.	Jan.
Broken Hill British	Tons lead carb. ore	365	370
	Tons lead conc.	1,140	2,234
	Tons zinc conc.	1,040	1,810
Broken Hill Prop.	Tons lead conc.	1,188	1,437
	Tons zinc conc.	4,863	5,895
Broken Hill South	Tons lead conc.	3,471	6,234
Burma Corporation	Tons refined lead	3,055	3,202
	Oz. refined silver	318,800	355,573
Electrolytic Zinc	Tons zinc	—	3,020†
Mount Lyell	Tons copper	782*	576
	Oz. silver	18,168*	12,206
	Oz. gold	540*	345
North Broken Hill	Tons lead conc.	885	1,630
	Tons zinc conc.	960	1,590
Pilbara	Tons copper ore	60	—
Poderosa	Tons copper ore	—	490
Rhodesia Broken Hill	Tons lead	1,169	1,848
Sulphide Corporation	Tons lead conc.	2,394	2,101
	Tons zinc conc	4,282	3,953
Tanganyika	Tons copper	2,980	3,055
Zinc Corporation	Tons zinc conc.	8,915	8,745
	Tons lead conc.	795	722

* Eight weeks to January 11.
† Period November 22 to February 8.

Imports of Ores, Metals, etc., into United Kingdom.

		Year 1921	Jan., 1922
Iron Ore	Tons	1,887,574	193,244
Manganese Ore	Tons	172,856	3,806
Iron and Steel	Tons	1,645,531	88,727
Copper and Iron Pyrites	Tons	288,440	26,441
Copper Ore, Matte, and Prec.	Tons	30,833	1,309
Copper Metal	Tons	86,810	6,005
Tin Concentrate	Tons	21,588	2,432
Tin Metal	Tons	20,967	3,147
Lead, Pig and Sheet	Tons	132,602	19,113
Zinc (Spelter)	Tons	72,486	6,908
Zinc Sheets, etc.	Tons	11,031	884
Quicksilver	Lb.	1,640,585	105,140
Zinc Oxide	Tons	4,489	241
White Lead	Cwt.	72,298	8,042
Barytes, ground	Cwt.	294,467	50,851
Asbestos	Tons	—	830
Phosphate of Lime	Tons	369,896	38,516
Mica	Tons	1,481	40
Sulphur	Tons	9,637	41
Nitrate of Soda	Cwt.	1,116,612	45,880
Petroleum: Crude	Gallons	99,592,619	19,225,267
Lamp Oil	Gallons	149,348,313	11,145,846
Motor Spirit	Gallons	251,098,155	25,788,604
Lubricating Oil	Gallons	50,966,045	7,981,430
Gas Oil	Gallons	76,826,082	10,046,813
Fuel Oil	Gallons	533,131,807	22,253,698
Asphalt and Bitumen	Tons	—	10,226
Paraffin Wax	Cwt.	784,686	55,575
Turpentine	Cwt.	308,464	24,047

Outputs of Tin Mining Companies.

In Tons of Concentrate.

	Nov.	Dec.	Jan.
Nigeria:	Tons	Tons	Tons
Associated Nigerian	—	—	—
Bisichi	45	50	33
Ex-Lands	30	—	—
Filani	3	3	1¾
Gold Coast Consolidated	2	2½	3
Gurum River	12	10	9
Jos	8	9	9
Kaduna	21¼	17½	22
Kaduna Prospectors	16¼	16	15¾
Keffi Consolidated	25	25	22
Lower Bisichi	4½	4¼	4½
Mongu	59	52	56¼
Naraguta	55	70	60
Naraguta Extended	20	22	12
Nigerian Consolidated	9	13¼	10¼
N.N. Bauchi	60	52	50
Rayfield	50	63	37
Ropp	135	125	109
Rukuba	3	4	4
South Bukeru	11	—	12
Tin Fields	—	—	—
Yarde Kerri	7	6	9
Federated Malay States:			
Chenderiang		74*	—
Gopeng	89	71½	71½
Idris Hydraulic	21½	22	23¾
Ipoh	15½	20¼	21
Kamunting	—	71*	—
Kinta	39	41¾	38¾
Lahat	48¾	53½	27½
Malayan Tin	89	76	68½
Pahang	214	252	251
Rambutan	19½	20	21
Sungei Besi	54	54	36
Tekka	38	36	36
Tekka-Taiping	24	24	21
Tronoh	30	28½	17
Other Countries:			
Aramayo Mines (Bolivia)	264	308	250
Berenguela (Bolivia)	41	42	41
Briseis (Tasmania)	20	—	—
Deebook Ronpibon (Siam)	21	16½	—
Leeuwpoort (Transvaal)	—	85*	—
Macreedy (Swaziland)	—	—	—
Renong (Siam)	115	100½	82
Rooiberg Minerals (Transvaal)	—	—	—
Siamese Tin (Siam)	166	142	103¾
Tongkah Harbour (Siam)	60	87	95
Zaaiplaats (Transvaal)	—	—	—

* Three months.

Nigerian Tin Production.

In long tons of concentrate of unspecified content.

Note.—These figures are taken from the monthly returns made by individual companies reporting in London, and probably represent 85% of the actual outputs.

	1917	1918	1919	1920	1921	1922
	Tons	Tons	Tons	Tons	Tons	Tons
January	667	678	613	547	438	473
February	646	668	623	477	370	—
March	655	707	606	505	445	—
April	555	584	546	467	394	—
May	509	525	483	383	337	—
June	473	492	484	435	423	—
July	479	545	481	484	494	—
August	551	571	616	447	477	—
September	538	520	561	528	595	—
October	578	491	625	62o	546	—
November	621	472	536	544	564	—
December	655	518	511	577	555	—
Total	6,927	6,771	6,685	6,022	5,618	473

Production of Tin in Federated Malay States.

Estimated at 70% of Concentrate shipped to Smelters
Long Tons.

	1918	1919	1920	1921	1922
	Tons	Tons	Tons	Tons	Tons
January	3,030	3,765	4,265	3,298	3,143
February	3,197	2,734	3,014	3,111	—
March	2,609	2,819	2,770	2,190	—
April	3,308	2,858	2,606	2,692	—
May	3,332	3,407	2,741	2,884	—
June	3,070	2,877	2,940	2,752	—
July	3,373	3,756	2,824	2,734	—
August	3,259	2,956	2,786	3,051	—
September	3,157	3,161	2,734	2,338	—
October	2,870	3,221	2,837	3,161	—
November	3,132	2,972	2,573	2,800	—
December	3,022	2,409	2,838	3,435	—
	37,370	36,935	34,928	34,446	3,143

Stocks of Tin.

Reported by A. Strauss & Co. Long Tons.

	Dec. 31	Jan. 31	Feb. 28
Straits and Australian Spot	2,019	1,823	1,668
Ditto, Landing and in Transit	635	745	627
Other Standard, Spot and Landing	5,196	5,518	5,175
Straits, Afloat	1,575	1,175	875
Australian, Afloat	70	75	190
Banca, in Holland	5,143	5,241	4,766
Ditto, Afloat	560	737	600
Billiton, Spot	121	166	100
Billiton, Afloat	—	—	—
Straits, Spot in Holland and Hamburg	—	—	—
Ditto, Afloat to Continent	425	350	500
Total Afloat for United States	6,833	8,235	8,527
Stock in America	1,696	1,321	1,406
Total	24,273	25,346	24,434

Shipments, Imports, Supply, and Consumption of Tin.

Reported by A. Strauss & Co. Long tons.

	Dec.	Jan.	Feb.
Shipments from:			
Straits to U.K.	1,825	1,125	875
Straits to America	3,700	4,020	2,255
Straits to Continent	395	270	510
Straits to other places	50	50	305
Australia to U.K.	220	210	200
U.K. to America	2,150	1,639	975
Imports of Bolivian Tin into Europe	1,032	811	770
Supply:			
Straits	5,920	5,515	3,565
Australian	250	210	200
Billiton	—	5	—
Banca	1,605	1,910	1,038
Standard	1,086	316	587
Total	8,861	7,956	5,390
Consumption:			
U.K. Deliveries	1,766	1,897	2,228
Dutch ,,	241	144	426
American ,,	3,710	4,275	3,215
Straits, Banca & Billiton, Continental Ports, etc.	1,170	567	433
Total	6,887	6,883	6,302

Imports and Exports of Gold and Silver

During January, 1922.

		Imports.	Exports.
Gold:	Unrefined Bullion £	3,453,996	—
	Refined Bars ,,	124,426	3,603,421
	Coin ,,	26	233,036
Silver:	Unrefined Bullion oz.	439,487	—
	Refined Bars ,,	1,292,640	4,450,626
	Coin £	83,824	194,648

Outputs Reported by Oil-producing Companies.

		Nov.	Dec.	Jan.
Anglo-Egyptian	Tons..	13,959	14,039	10,254
Anglo-United	Barrels	9,500	8,302	6,700
Apex Trinidad	Barrels	—	17,233	38,799
British Burmah	Barrels	71,050	73,300	71,735
Caltex	Tons..	12,761	17,660	10,443
Dacia Romana	Tons..	245	201	304
Kern River	Barrels	117,125	119,796	110,627
Lobitos	Tons..	8,716	8,821	9,003
Roumanian Consolidated	Tons..	1,800	1,633	1,600
Santa Maria	Tons..	1,571	1,671	12,500*
Steaua Romana	Tons..	17,600	19,399	18,101
Trinidad Leaseholds	Tons..	18,000	13,250	10,800
United of Trinidad	Tons..	4,889	3,471	3,398

* Barrels.

Quotations of Oil Companies' Shares.

Denomination of Shares £1 unless otherwise noted.

	Jan. 5, 1922			Feb. 6, 1922		
	£	s.	d.	£	s.	d.
Anglo-American	4	2	6	4	0	0
Anglo-Egyptian B	1	8	9	1	10	0
Anglo-Persian 1st Pref.	1	3	0	1	3	6
Apex Trinidad	1	17	6	1	12	6
British Borneo (10s.)		8	9		11	3
British Burmah (8s.)		16	3		15	0
Burmah Oil	5	17	6	5	10	0
Caltex ($1)		3	0		3	0
Dacia Romano		13	9		13	9
Kern River, Cal. (10s.)		18	6	1	0	6
Lobitos, Peru	4	5	0	4	10	0
Mexican Eagle, Ord. ($5)	3	11	3	3	17	6
,, ,, Pref. ($5)	3	8	9	3	15	0
North Caucasian (10s.)		15	0		15	0
Phœnix, Roumania		11	0		14	0
Roumanian Consolidated		9	6		8	0
Royal Dutch (100 gulden)	36	0	0	35	10	0
Scottish American		2	6		2	0
Shell Transport, Ord.	4	12	6	4	12	6
,, ,, Pref. (£10)	8	7	6	8	15	0
Trinidad Central	3	8	9	3	6	0
Trinidad Leaseholds	1	10	0	1	5	0
United British of Trinidad		13	9		12	6
Ural Caspian		15	0		15	0
Uroz Oilfields (10s.)		6	6		5	3

Petroleum Products Prices. March 9.

Refined Petroleum: Water white, 1s. 2d. per gallon; standard white, 1s. 1d. per gallon; in barrels 3d. per gallon extra.

Motor Spirit: In bulk: Aviation spirit, 2s. 6d. per gallon; No. 1, 2s. 2d. per gallon; No. 2, 2s. per gallon.

Fuel Oil: Furnace fuel oil, £3 12s. 6d. per ton; Diesel oil, £5 per ton.

American Oils: Best Pennsylvania crude at wells, $3·25 per barrel. Refined standard white for export in bulk, 7 cents per U.S. gallon; in barrels 13 cents. Refined water white for export in bulk, 8 cents per U.S. gallon; in barrels 14 cents.

Dividends Declared by Mining Companies

During month ended March 10.

Company	Par Value of Shares	Amount of Dividend
Borax Consolidated	Def. Ord. £1	1s. 6d. less tax.
Gold Mines Investment	£1	6d. less tax.
Kalgurli Gold	£1	12s. 6d.*
Mysore Gold	10s.	1s. 6d. less tax.
North Anantapur	Pref. £1	20% less tax.
Nechi (Colombia)	Ord. 10s.	5s. less tax.
	Pref. 10s.	1s. 3d. less tax.
Oroville Dredging	£1	9d. less tax.
South African Gold Trust	Ord. £1	5% less tax.
Witbank Colliery	£1	2s. less tax.

* Distribution of Capital on Liquidation.

PRICES OF CHEMICALS. March 7.

These quotations are not absolute; they vary according to quantities required and contracts running.

		£	s.	d.
Acetic Acid, 40%	per cwt.	1	1	0
,, 80%	,,	2	2	0
,, Glacial	per ton	55	0	0
Alum	,,	14	0	0
Alumina, Sulphate	,,	12	10	0
Ammonia, Anhydrous	per lb.		2	2
,, 0·880 solution	per ton	26	0	0
,, Carbonate	per lb.			4
,, Chloride, grey	per ton	37	0	0
,, ,, pure	per cwt.	3	5	0
,, Nitrate	per ton	40	0	0
,, Phosphate	,,	75	0	0
,, Sulphate	,,	16	0	0
Antimony, Tartar Emetic	per lb.		1	6
,, Sulphide, Golden	,,		1	3
Arsenic, White	per ton	38	0	0
Barium Carbonate	,,	6	0	0
,, Chlorate	per lb.			7
,, Chloride	per ton	15	0	0
,, Sulphate	,,	8	0	0
Benzol, 90%	per gal.		2	4
Bisulphide of Carbon	per ton	50	0	0
Bleaching Powder, 35% Cl.	,,	14	0	0
,, Liquor, 7%	,,	5	0	0
Borax	,,	31	0	0
Boric Acid Crystals	,,	65	0	0
Calcium Chloride	,,	8	0	0
Carbolic Acid, crude 60%	per gal.		1	7
,, ,, crystallized, 40°	per lb.			6
China Clay (at Runcorn)	per ton	4	10	0
Citric Acid	per lb.		2	0
Copper, Sulphate	per ton	28	0	0
Cyanide of Sodium, 100%	per lb.			11
Hydrofluoric Acid	,,			7½
Iodine	per oz.		1	0
Iron, Nitrate	per ton	8	0	0
,, Sulphate	,,	3	0	0
Lead, Acetate, white	,,	41	0	0
,, Nitrate	,,	46	0	0
,, Oxide, Litharge	,,	35	0	0
,, White	,,	44	0	0
Lime, Acetate, brown	,,	7	10	0
,, ,, grey 80%	,,	12	10	0
Magnesite, Calcined	,,	21	0	0
Magnesium, Chloride	,,	11	0	0
,, Sulphate	,,	8	0	0
Methylated Spirit 64° Industrial	per gal.		4	0
Nitric Acid, 80° Tw.	per ton	27	0	0
Oxalic Acid	per lb.			8
Phosphoric Acid	per ton	50	0	0
Potassium Bichromate	per lb.			8
,, Carbonate	per ton	23	0	0
,, Chlorate	per lb.			5
,, Chloride 80%	per ton	12	0	0
,, Hydrate (Caustic) 90%	,,	33	0	0
,, Nitrate	,,	43	0	0
,, Permanganate	per lb.			8
,, Prussiate, Yellow	,,		1	3
,, ,, Red	,,		3	0
,, Sulphate, 90%	per ton	15	0	0
Sodium Metal	per lb.		1	4
,, Acetate	per ton	25	0	0
,, Arsenate 45%	,,	44	0	0
,, Bicarbonate	,,	12	0	0
,, Bichromate	per lb.			6
,, Carbonate (Soda Ash)	per ton	15	0	0
,, ,, (Crystals)	,,	6	10	0
,, Chlorate	per lb.			4
,, Hydrate, 76%	per ton	26	10	0
,, Hyposulphite	,,	12	0	0
,, Nitrate, 96%	,,	14	0	0
,, Phosphate	,,	18	0	0
,, Prussiate	per lb.			10
,, Silicate	per ton	11	15	0
,, Sulphate (Salt-cake)	,,	4	0	0
,, ,, (Glauber's Salts)	,,	4	10	0
,, Sulphide	,,	22	0	0
,, Sulphite	,,	12	10	0
Sulphur, Roll	,,	10	10	0
,, Flowers	,,	10	10	0
Sulphuric Acid, Fuming, 65°	,,	24	0	0
,, ,, free from Arsenic, 144°	,,	6	5	0
Superphosphate of Lime, 30%	,,	4	10	0
Tartaric Acid	per lb.		1	5
Turpentine	per cwt.	3	3	6
Tin Crystals	per lb.		1	3
Titanous Chloride	,,		1	0
Zinc Chloride	per ton	22	10	0
Zinc Oxide	,,	41	0	0
Zinc Sulphate	,,	16	0	0

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD, SILVER, DIAMONDS:	March 7, 1921 £	s.	d.	March 6, 1922 £	s.	d.
RAND:						
Brakpan	2	10	0	2	2	6
Central Mining (£8)	6	2	6	5	17	6
City & Suburban (£4)		6	9		2	6
City Deep	2	0	0	2	2	6
Consolidated Gold Fields		16	3		15	0
Consolidated Langlaagte		12	6		12	6
Consolidated Main Reef		10	3		8	9
Consolidated Mines Selection (10s.)		13	9		12	6
Crown Mines (10s.)	2	0	0	1	15	0
Daggafontein		2	6		2	6
Durban Roodepoort Deep		2	6		3	9
East Rand Proprietary		5	0		4	9
Ferreira Deep		9	0		7	9
Geduld	2	5	0	2	12	6
Geldenhuis Deep		6	0		5	3
Government Gold Mining Areas	3	15	0	3	17	6
Johannesburg Consolidated	1	2	0	1	2	6
Kleinfontein		6	9		4	9
Knight Central		3	6		4	3
Langlaagte Estate		10	6		11	3
Luipaards Vlei		1	6		2	6
Meyer & Charlton	4	2	6	3	7	6
Modderfontein, New (10s.)	3	5	0	3	8	9
Modderfontein B (5s.)	1	5	0	1	6	3
Modderfontein Deep (5s.)	2	0	0	2	1	3
Modderfontein East		17	6		6	6
New State Areas	1	2	6	1	6	3
Nourse		6	9		11	6
Rand Mines (5s.)	2	2	6	2	1	3
Rand Selection Corporation	2	5	0	2	7	6
Randfontein Central		8	6		11	9
Robinson (£5)		9	3		8	6
Robinson Deep A (1s.)		11	3		7	6
Rose Deep		12	6		11	9
Simmer & Jack		2	6		2	9
Springs	1	12	6	1	18	9
Sub-Nigel		11	3		12	3
Union Corporation (12s. 6d.)		16	0		16	3
Van Ryn		11	3		9	9
Van Ryn Deep	3	2	6	3	2	6
Village Deep		7	0		7	3
West Springs		15	0		7	6
Witwatersrand (Knight's)		11	3		12	0
Witwatersrand Deep		6	9		7	9
Wolhuter		3	9		3	0
OTHER TRANSVAAL GOLD MINES:						
Glynn's Lydenburg		8	9		6	3
Transvaal Gold Mining Estates		8	3		7	6
DIAMONDS IN SOUTH AFRICA:						
De Beers Deferred (£2 10s.)	9	15	0	10	10	0
Jagersfontein	1	17	6	2	5	0
Premier Deferred (2s. 6d.)	4	5	0	4	15	0
RHODESIA:						
Cam & Motor		7	6		7	3
Chartered British South Africa		12	0		12	6
Falcon		6	6		3	6
Gaika		8	6		9	0
Globe & Phœnix (5s.)		18	6		11	0
Lonely Reef	1	17	6	2	1	3
Rezende	2	12	6	2	2	6
Shamva	1	7	6	1	8	9
WEST AFRICA:						
Abbontiakoon (10s.)		2	0		2	3
Abosso		8	0		7	0
Ashanti (4s.)		11	3		13	3
Prestea Block A		1	6		1	0
Taquah		7	6		7	9
WEST AUSTRALIA:						
Associated Gold Mines		2	6		5	9
Associated Northern Blocks		2	6		2	3
Bullfinch (5s.)			6		1	0
Golden Horse Shoe (£5)		12	6		11	3
Great Boulder Proprietary (2s.)		5	6		5	6
Great Fingall (10s.)		1	6		1	0
Hampton Celebration		3	9		4	3
Hampton Properties		6	3		4	6
Ivanhoe (£5)		18	9		18	9
Kalgurli		7	6		—	
Lake View Investment (10s.)		9	0		8	3
Lake View and Star (4s.)		1	6		1	9
Oroya Links (5s.)		1	3		1	3
Sons of Gwalia		5	0		3	0
South Kalgurli (10s.)		5	6		5	6
GOLD, SILVER, cont.						
NEW ZEALAND:						
Blackwater		2	6		2	6
Waihi	1	6	3		17	6
Waihi Grand Junction		7	6		6	3
AMERICA:						
Buena Tierra, Mexico		5	0		1	9
Camp Bird, Colorado		5	6		3	0
El Oro, Mexico		10	0		9	0
Esperanza, Mexico		16	3		14	6
Frontino & Bolivia, Colombia		8	9		5	0
Kirkland Lake, Ontario		13	0		11	9
Le Roi No. 2 (£5), British Columbia		5	0		2	6
Mexico Mines of El Oro, Mexico	4	8	9	3	12	6
Nechi (Pref. 10s.), Colombia		6	3		5	0
Oroville Dredging, Colombia	1	2	6	1	3	9
Plymouth Consolidated, California		17	6		5	0
St. John del Rey, Brazil		15	0		16	0
Santa Gertrudis, Mexico		7	3		4	6
Tomboy, Colorado		6	3		6	3
RUSSIA:						
Lena Goldfields		8	9		8	9
Orsk Priority		5	0		5	0
INDIA:						
Balaghat (10s.)		7	6		7	0
Champion Reef (2s. 6d.)		2	3		3	6
Mysore (10s.)		12	6		12	3
North Anantapur		5	0		2	6
Nundydroog (10s.)		6	0		8	6
Ooregum (10s.)		12	6		13	9
COPPER:						
Arizona Copper (5s.), Arizona	1	3	9		15	0
Cape Copper (£2), Cape and India		15	0		7	6
Esperanza, Spain		5	0		4	6
Hampden Cloncurry, Queensland		5	0		5	0
Mason & Barry, Portugal	1	10	0	2	0	0
Messina (5s.), Transvaal		4	0		3	0
Mount Elliott (£5), Queensland		7	6	1	0	0
Mount Lyell, Tasmania		11	3		12	6
Mount Morgan, Queensland		11	3		12	3
Namaqua (£2), Cape Province		17	6	1	2	6
Rio Tinto (£5), Spain	24	0	0	25	0	0
Russo-Asiatic Consd., Russia		7	9		9	3
Sissert, Russia		5	0		4	6
Spassky, Russia		19	0		11	3
Tanganyika, Congo and Rhodesia	1	2	6		18	6
LEAD-ZINC:						
BROKEN HILL:						
Amalgamated Zinc		15	0		11	3
British Broken Hill		15	0	1	0	0
Broken Hill Proprietary	1	15	0	1	1	3
Broken Hill Block 10 (£10)		10	0		7	6
Broken Hill North	1	2	6	1	5	0
Broken Hill South	1	1	3	1	5	0
Sulphide Corporation (15s.)		11	3		17	6
Zinc Corporation (10s.)		7	6		8	6
ASIA:						
Burma Corporation (10 rupees)		7	3		5	6
Russian Mining		5	0		4	6
RHODESIA:						
Rhodesia Broken Hill (5s.)		6	0		5	3
TIN:						
Aramayo Mines, Bolivia	1	15	0	1	17	6
Bisichi (10s.), Nigeria		6	3		5	6
Briseis, Tasmania		2	6		3	3
Chenderiang, Malay		13	0		11	3
Dolcoath, Cornwall			6			9
East Pool (5s.), Cornwall		2	6		2	6
Ex-Lands Nigeria (2s.), Nigeria		2	0		1	6
Geevor (10s.), Cornwall		3	9		3	0
Gopeng, Malay	1	10	0	1	13	9
Ipoh Dredging, Malay		11	3		8	9
Kamunting, Malay	1	7	0	1	1	3
Kinta, Malay	1	10	0	1	15	0
Lahat, Malay	1	7	6		7	6
Malayan Tin Dredging, Malay	1	2	6	1	2	6
Mongu (10s.), Nigeria		11	3		8	9
Naraguta, Nigeria		12	6		12	6
N. N. Bauchi, Nigeria (10s.)		1	9		1	6
Pahang Consolidated (5s.), Malay		6	0		5	0
Rayfield, Nigeria		3	6		2	0
Renong Dredging, Siam	1	5	0	1	1	3
Ropp (4s.), Nigeria		5	0		5	3
Siamese Tin, Siam	2	5	0	1	16	3
South Crofty (5s.), Cornwall		4	0		3	6
Tehidy Minerals, Cornwall		10	0		8	9
Tekka, Malay		17	6		15	0
Tekka-Taiping, Malay	1	1	3		17	6
Tronoh, Malay	1	5	0	1	2	6

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

In this section we give abstracts of important articles and papers appearing in technical journals and proceedings of societies, together with brief records of other articles and papers; also notices of new books and pamphlets, lists of patents on mining and metallurgical subjects, and abstracts of the yearly reports of mining companies.

SILVER ORES OF SOUTH LORRAIN, ONTARIO

At the meeting of the Institution of Mining and Metallurgy held on February 16, Dr. J. Mackintosh Bell read a paper on the silver ore deposits of South Lorrain, 16 miles south-east of Cobalt, Ontario, more particularly in connexion with the Keeley mine of which he is manager (Fig. 1). These deposits were first discovered in 1907, and the first producer was the Wettlaufer, which did well in the early days. By 1912 the known ores were exhausted, and it was thought the district had come to an end. At that time Dr. Bell paid a visit, and the results of his geological investigations indicated that ore would be found at certain places. On his recommendation the Keeley claims were acquired by the Associated Gold Mines of West Australia, Ltd. The war, however, interfered with development, and it was not until 1920 that active work was undertaken. The mine commenced production in 1921. In giving extracts from Dr. Bell's paper herewith, we may mention that he gave a brief account of the Lorrain district in the MAGAZINE for February, 1914.

General Geology.—Practically the same geological sequence of rocks as is found at Cobalt is represented in South Lorrain. It may be briefly summarized as follows, the figures 1 to 5 representing the sequence from the oldest to the youngest :—

(1) KEEWATIN COMPLEX .	The most ancient rocks of the district, consisting mainly of of schists and greenstone, but containing in minor amount banded ferruginous cherts.
(2) LAMPROPHRYE DYKES	
(3) LORRAIN GRANITE .	
(4) COBALT SERIES . .	Including conglomerate, greywacke, and other fragmental rocks.
(5) NIPISSING DIABASE .	

Rocks of the Temiskaming series, consisting of conglomerates and other fragmentals which unconformably overlie the Keewatin near Cobalt, have not been found in South Lorrain, nor are there any exposures of Silurian strata in the locality, such as are common on the islands of Lake Temiskaming and elsewhere farther to the north. At Cobalt the silver-bearing veins occur in rocks of the Keewatin complex and of the Cobalt series and in the Nipissing diabase, though more than 90% of the production has come from one geological formation, the Cobalt conglomerate, of the Cobalt series. In South Lorrain the silver veins are limited to Keewatin rocks and associated lamprophyre dykes, and to the diabase. The ore of the Wettlaufer mine was found only in the diabase, while in the Keeley and Haileybury Frontier mines it occurs in both diabase and Keewatin rocks.

The Keewatin series in the vicinity of the mines of South Lorrain is represented by greenstone, which is ordinarily of such fine texture and so much metamorphosed that its original character is generally difficult of diagnosis. Petrologically, a range from acid andesite or dacite to basalt is found both in the form of lavas and of volcanic sediments. The coarse amphibolite phase of the Keewatin is not found near the mines.

The lamprophyre dykes, which ramify in all directions through the Keewatin rocks, are, in places in proximity to the veins, difficult to distinguish below ground from altered Nipissing diabase in the same position, but ordinarily the considerable shearing of the lamprophyre, together with large flakes of an altered mica and of chlorite therein, serve to differentiate the two. Dykes of an acid rock, locally known as "aplite" which it seems to resemble closely, cut the Keewatin rocks in places, but are rarely found near the mines. While they are thought to represent residual acid segregations from the Nipissing diabase, their actual genetic connexion with the latter in South Lorrain has not yet been proved.

The diabase of South Lorrain is petrologically identical with that of Cobalt. It is commonly sufficiently coarse to exhibit macroscopically the characteristic ophitic structure. The presence of quartz shows it to be essentially a quartz-diabase. The diabase occurs in the form of a wide sill which has apparently been folded into a broad dome and truncated by erosion. The silver-bearing veins are associated with the westerly-dipping limb of the fold (either in the diabase itself or in the Keewatin rocks beneath which the diabase plunges) for a length along the contact of about a mile. On the property of the Keeley Silver Mines, Ltd., the surface of the eastern half of the claim is composed of diabase, while the remainder of that claim and the whole of the surface of the Beaver Lake claim consists of Keewatin rocks.

The strike of the contact of the Keeley claim is approximately north and south and the dip invariably westerly at an angle varying from 10° to 30°. Two reverse faults (one along No. 6 vein, and the other along Wood's vein) traverse the Keeley property from north to south and step the sill farther downward to the west (see Fig. 2). The throw of the fault along No. 6 vein is only a few feet, but that along Wood's vein is not less than 50 ft. Other faults, approximately at right angles to these two, with minor rolls in the diabase transverse to its dip, and cross zones of fracturing showing in both diabase and overlying Keewatin rocks, serve to further complicate the structure. It is noteworthy that the greenstone, though much fractured and jointed, is not ordinarily schistose, but rather is fissile in character.

The Vein System.—What may be described as the mother lode of South Lorrain is Wood's vein, which is traceable for over a mile in length from the

Trout Lake claim on the south to the Formi claim on the north (Fig. 1). Its strike is approximately north and south, that is, roughly parallel to the diabase-Keewatin surface contact on the Keeley property, though not so farther north where the line of contact diverges to the eastward. The pronounced fault, which Wood's vein occupies, resembles the Cobalt Lake fault in being the fracture of paramount control in influencing the distribution of the veins, but it differs therefrom in the remarkable strength of the vein-material contained and in the much smaller quantity of gouge. With a general parallelism to Wood's vein, the locality shows a number of other north-and-south veins, while roughly at right angles are a multiplicity of branching veins known as the transverse veins. The position of the principal of the numerous veins on the Keeley property is shown in Fig. 3.

On the Keeley property, Wood's vein does not always occupy a single fracture, but commonly a fractured zone which in places is 10 ft. in width. Vein-material may be only a few inches wide, and be limited to the pronounced foot or hanging wall, or it may extend from wall to wall. The vein to the greatest depth so far explored (420 ft.) has an average dip easterly of about 65°, but variations of 15° from this inclination are common. Wood's vein is nowhere exposed at the surface, but its outcrop is plainly traceable on the Keeley property by a well-demarcated swampy valley considerably depressed below the general level of the surrounding hilly country.

East of Wood's vein on the Keeley property, and striking approximately north and south with a general parallelism to it, is No. 6 vein, connected with Wood's vein towards the south by a number of branching stringers. Eastward of No. 6 vein, a roughly north-and-south depression known as Harris Valley is believed to represent the surface expression of a third prominent north-and-south vein. Similarly, westward of Wood's vein are at least two pronounced depressions connected with Wood's Valley beneath which it is probable other north-and-south veins will be found. Transverse to the north and south veins are a large number of veins, Nos. 1, 2, 4, 5, 8, 14, 15, and 16 being the most conspicuous. Generally speaking, the transverse veins are steeper in dip than the north-and-south veins, but there are many variations from this rule. No. 6 vein, for instance, near the surface dips westerly, while at 360 ft. below it is dipping easterly, and at greater depth it is vertical. No. 9 vein runs practically parallel to No. 6 and Wood's for most of its course, but abruptly turns and joins No. 6 on the strike.

All of the north-and-south veins, with the exception of the supposed vein beneath Harris Valley, which is entirely in diabase, are at the surface in Keewatin rocks, and, as the sill dips westerly, the veins in crossing from east to west intersect the contact at increasingly greater depth. No. 6 vein and Wood's are the only north-and-south veins which have been developed at all at or near the contact. The former is not exactly parallel to the strike of the contact, but, roughly speaking, it may be said to intersect the diabase on the hanging or eastern wall at 350 ft. Wood's vein at 420 ft. has diabase on the hanging and Keewatin on the foot or western wall. The exact point at which the roof of the sill reaches Wood's vein on the hanging-wall is not yet known, as no ore has yet been extracted between the present lowest level (420 ft.) and the horizon above. Similarly, the depth of the roof of the sill on the down-faulted or foot-wall side is not yet known.

Certain of the transverse veins occupy undoubted fault fissures ; in others there seems to be no dislocation. Joint-planes with thin selvages of vein material are common, but so far have not been found to carry commercial ore.

While most of the veins which have been prospected on the Keeley property show only superficial oxidation, Nos. 1 and 2 veins in the northern part of the property are slightly oxidized to a depth of 120 ft., and the southern portion of Wood's vein shows intense oxidation to the greatest depth yet attained (420 ft.), a condition, as far as is known to the writer, unique in the Cobalt district. The northern limit of oxidation on Wood's vein, which is quite abruptly demarcated, pitches steeply northward to about 350 ft., and from that depth to the deepest horizon of the mine (420 ft.) deeply southward. Not only is Wood's vein itself oxidized, but the oxidation extends into the foot-wall for an unknown distance, and the branching stringers on the hanging wall connecting the parent vein with No. 6 show a similar change. It is obvious that such extensive oxidation, even along so strong a line of fracturing, cannot be post-glacial, but must have ante-dated the glacial epoch. The greater depth to which oxidation extends in the southern than in the northern part of Wood's vein is probably to be connected with the influence on the parent vein and its numerous branches of the position of the water-level in a pre-glacial topography, the nature of which is not now clear. It seems possible that glacial denudation was not as great in South Lorrain generally as at Cobalt, and that in the southern and particularly narrow part of the depression occupied by Wood's vein protection against corrosion was given by the walls of greenstone on either side, especially after the depression had been filled by débris with the initial advance of the ice.

The Vein Material.—Though most of the veins of the Keeley mine show for relatively long distances considerable widths of vein-material, each of them, even Wood's, is in places represented merely by a narrow crack containing a puggy selvage but devoid of vein-material proper. With the exception of Wood's (the width of which is quite exceptional) the vein-material proper is not ordinarily more than 2 or 3 ft. wide, and is generally less. In places, however, the veins are not represented by a single stringer of vein-material, but by two or more stringers occurring in fractured rock, over a width of 4 ft. or more. Where the vein carries ore this fractured rock is ordinarily impregnated with silver values in the form of leaf silver, or fine ruby silver and argentite.

Much of the vein-material is composed of country rock more or less replaced by carbonates and metallic minerals, or otherwise altered. The non-metallic minerals in the unoxidized portions of the veins are similar to those of Cobalt, calcite, dolomite, and quartz being the most common. Apatite, tremolite, and biotite are rare. A dense hard whitish, pinkish, greyish, or deep salmon-coloured material, which is common in the veins and when variegated is of great beauty, is apparently a silicified carbonate, chiefly of lime, but generally with more or less magnesia, manganese, or iron present.

The metallic minerals are of great variety, smaltite, cobaltite, chloanthite, niccolite, pyrite, marcasite, mispickel, chalcopyrite, native silver, argentite, ruby silver in various forms, native bismuth, and stromeyerite all being common; covellite, galena, zinc-blende, and dyscrasite are rare.

Though the veinstone seems to have been largely due to replacement, it is evident by the crustified or drusy character visible in places in all of the veins that there must have been a considerable amount of deposition in open spaces. From a purely economic point of view, one of the most interesting types of veinstone is a dense blackish or dark greyish material, which is ordinarily finely banded. This material consists of quartz and calcite containing chlorite residual from the original country rock, smaltite, and generally very fine silver either free or enclosed in smaltite. As the veinstone of

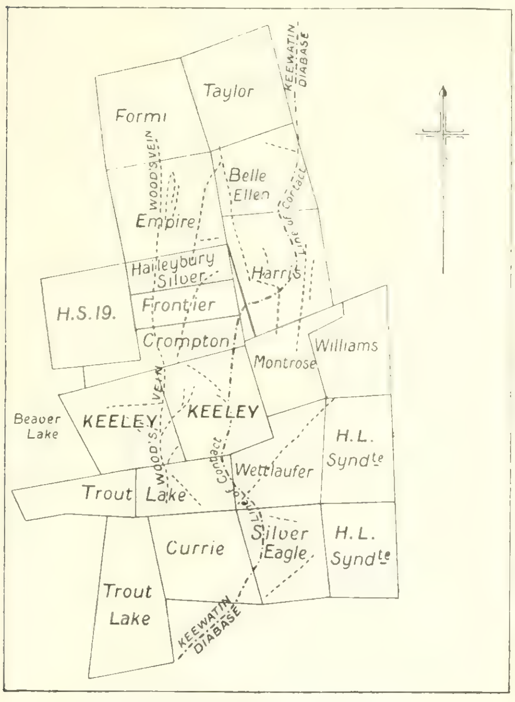


FIG. 1.—MINING CLAIMS AT SOUTH LORRAIN.

this character is frequently the precursor of high-grade ore, the miners speak of it as the "pay-streak."

In the oxidized zone, the veinstone consists largely of soft puggy, highly decomposed, rusty material, accompanied by annabergite and erythrite, which are especially conspicuous near the surface, and found, though rarely, even to the greatest depth yet reached in the mine. Copper carbonates are infrequently seen. The silver in the oxidized zone occurs ordinarily in the form of very fine, rusty, rounded flakes, but masses of the native minerals and of argentite occur, as well as wire silver.

The average run of mill ore from the veins carries about 20 oz. of silver to the ton, but from this has been picked most of the high-grade ore, which varies in richness from about 100 oz. to the ton to upwards of 5,000 oz. and averages about 2,000 oz. The mill ore is composed of veinstone low in silver values, or of country rock impregnated with leaf silver and ruby silver, bordering shoots of high-grade ore. The width of this impregnated material is ordinarily more in Keewatin rocks than in diabase, owing to the greater fracturing of the former. The silver in the diabase wall-rock is frequently extremely fine.

The character of the high-grade ore shows many variations. It is ordinarily possible to distinguish on the mill picking-table that drawn from the

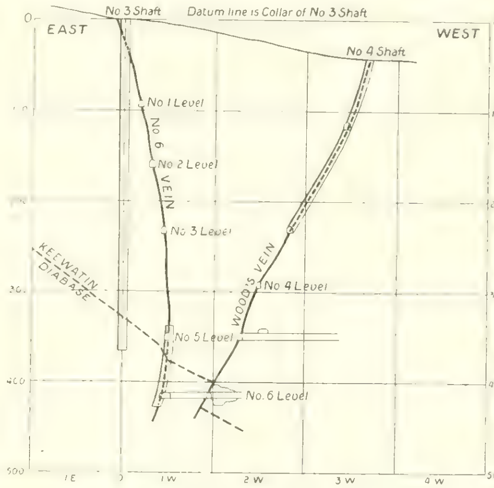


FIG. 2.—LONGITUDINAL VERTICAL SECTION, KEELEY MINE, BETWEEN NO. 3 AND NO. 4 SHAFTS.

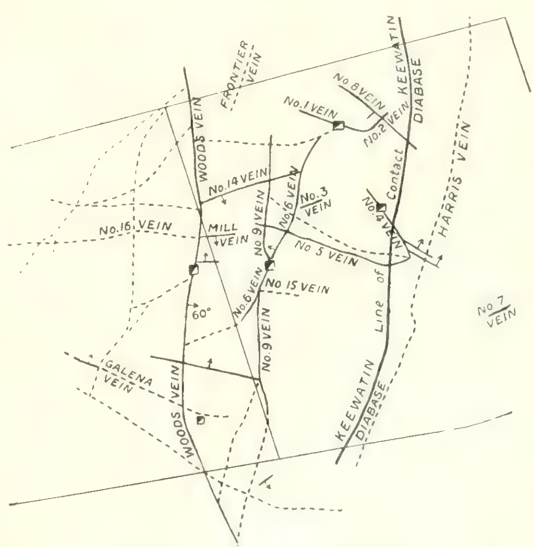


FIG. 3.—KEELEY MINE, SURFACE VEIN PLAN.

various veins, and even that from different horizons in any particular vein. For example, the high-grade ore of No. 16 vein (which carries the richest ore in the mine) consists at a depth of 420 ft. of argentite, partly replacing a remarkable width of smaltite and of wire silver in cavities, while at 70 ft. above it is composed of massive native silver in calcite associated with smaltite containing silver only in the form of ruby silver in cracks.

In the deepest working on Wood's vein (420 ft.), the high-grade ore generally consists of a finely crystalline light silvery-grey smaltite, through which native silver is distributed in greater or less quantity as relatively small crystalline flakes. It is noteworthy that more calcite is generally found with the high-grade ore in Wood's vein, where the vein is in diabase, than in Keewatin rocks or associated lamprophyre. In the upper unoxidized portion of Wood's vein the richest ore is at times an intergrowth of calcite and fine smaltite, seamed with cracks filled with heavy flake silver.

Great slabs of native silver up to 10 lb. in weight are found in one of the high-grade shoots of No. 6 vein. Seams filled with densely matted wire silver—called by the miners moss silver—from No. 6 vein and Wood's vein provide small quantities of rich material.

Position of the Ore-Shoots.—The ore-shoots in the silver-bearing veins of South Lorrain are ordinarily even less extensive than those of Cobalt. In the Keeley mine, where there are numerous ore-shoots, the largest so far discovered is on Wood's vein, with a length of 250 ft. at the lowest horizon of the mine (420 ft.) The ore-shoots all contain a certain amount of high-grade ore with the mill ore, and in many of the shoots in favourable horizons this rich material is much the more important from a value standpoint. In an ore-shoot at a favourable horizon, there may be two or three, or even more, patches of high-grade ore separated by considerable lengths of mill rock, or even short lengths of almost barren veinstone. The transition from very rich ore to barren veinstone at the confines of shoots (either laterally or up and down the dip) may be gradual through mill rock or extraordinarily abrupt. The patches of high-grade ore are commonly short, from 10 to 50 ft. in length.

Certain general features which govern the position of the ore-shoots at the Keeley mine, and also, having regard to geological differences, to a large extent elsewhere in the Cobalt district, may be stated.

(1) Generally speaking, the richest and most persistent ore-shoots occur at or near the diabase-Keewatin contact, either within the diabase or within the Keewatin; the immediate contact is commonly barren or of low grade.

(2) An ore-shoot in the Keewatin does not ordinarily persist down into the diabase; or, vice versa, one in the diabase extend upward into the Keewatin. In other words one part of a vein may carry ore in diabase, another in Keewatin.

(3) Gently inclined fractures, parallel to the contact and transverse to the dip of the veins, have an enriching effect upon the vein material.

(4) The junction of one vein with another, even a considerable distance from the contact, affects the values either in one vein or the other, or in both. If the veins are valueless before joining, a shoot of greater or less length is commonly made in the united vein.

(5) The values of a vein within sufficient distance of the contact, even in smaller veins, are likely to improve when the vein occurs in a well-fractured zone, with cracking developed parallel to its strike.

(6) Ore-shoots are frequently localized on a main vein between the points of departure or two minor branching veins, or between the points of crossing of two zones of fracturing.

(7) When the ore-shoots are in Keewatin rocks, the most favourable type is an extremely dense fissile well-fractured greenstone. Lamprophyre is generally much less favourable, though some of the richest ore is found in fault planes when greenstone occupies one wall and lamprophyre the other.

(8) Generally speaking, the veins are more likely to carry ore when the dip of the vein is steep (upwards of 70°) than when it is flat. Wood's vein, however, carries large amounts of ore when the dip is as low as 60°, or even less.

Wood's vein at a depth of 420 ft. has, as previously indicated, diabase on the hanging or eastern wall and Keewatin (with, in places, lamprophyre) on the foot-wall. The veinstone proper is in places on the Keewatin side of the fault and elsewhere on the diabase side. In both rocks rich ore is carried through the veinstone, but is of low grade where it passes from one to the other. Commercial ore occurs in the Keewatin rocks upward from this lowest horizon of the mine (420 ft.) at favourable positions to the surface, a range along the dip of the vein of about 475 ft.

As there is no development as yet below 420 ft., there is no information available to indicate the range below the contact to which ore will extend on Wood's vein, but some information is obtainable as to the downward extension elsewhere on the property from the fact that rich ore is found in No. 4 vein (a transverse ore-body) in diabase to a depth of at least 150 ft. below the contact. The known range of ore on the Keeley on both sides of the contact is, therefore, not less than 625 ft.

From the principles previously enumerated, it may be presumed that there is a steady depreciation in the extent and quality of the ore-shoots in Wood's vein in passing upward along the dip through the 475 ft. between the intersection with the contact (420 ft. vertical) and the surface. Such, however, does not seem to be the case, at any rate as far as development has up to the present proceeded. While shoots of excellent ore have been found from 475 ft. upward along the dip to about 350 ft. (getting poorer upward) and of good ore from the surface downward to about 250 ft. on the dip, it is noteworthy that in the approximate horizon between 250 ft. and 350 ft. very little ore has been developed. In other words, there is between these horizons a poor zone. There is thus evidence to assume that there are in Wood's vein at least two ore zones, one, apparently much the richer on either side of the contact in depth, and another extending downward from the surface. It goes without saying that the upward limit of the lower, and the downward limit of the upper, is not a plane surface but is highly irregular in outline. It is possible that the re-occurrence of ore upwards near the surface may be due in part to a slight change in the inclination of the vein, or to some other structural feature, but in Dr. Bell's opinion it is at least in part due to processes of secondary enrichment which is enlarged upon in a later paragraph.

Origin of the Deposits.—It is generally recognized by the writers on the genesis of the veins of the Cobalt district that their metallic contents are essentially of igneous origin. The same features which are applicable in this connexion at Cobalt itself are equally so in South Lorrain. In view of the fact that the diabase with which the veins are invariably associated had been solidified, folded, faulted, and otherwise affected by tectonic forces, prior to the deposition of the veins, it seems clear that their origin cannot be directly connected with hydro-thermal activity from the diabase itself. On the other hand, owing to the absence of the particular type of vein from localities where diabase does not occur, it is no less clear that there is some connexion with the diabase, and it seems therefore reasonable to assume that the origin of the veins may be traced to some deep-lying plutonic rock from the magma of which the diabase itself was in the first instance derived. A. R. Whitman, the high character of whose work at Cobalt is generally recognized, gives evidence, however, to suggest that the ore emanated from the diabase itself rather than from the mother-magma.

Dr. Bell agrees with previous writers (W. G. Miller, W. Campbell, C. W. Knight, and E. S. Bastin) as to the paragenesis of the principal original minerals of the veins, and as to the nature and origin of the primary mineralization.

The vein-material, mainly due to replacement, was in its initial form of hypogene origin. While the silver minerals seem to have been mainly introduced at a somewhat later stage (after minor movement had occurred) than the smaltite, niccolite, and calcite, their deposition was in the nature of delayed precipitation rather than an entirely distinct feature of mineralization. It is quite possible, in Dr. Bell's opinion, that a certain amount of silver deposition may have occurred at the same time as the precipitation of the cobalt and nickel arsenides.

S. F. Emmons was of opinion that the rich silver shoots of the Cobalt district proper were due to secondary enrichment by descending solutions. W. G. Miller, in the fourth edition of his report on the Cobalt district, is rather non-committal on the subject, but seems to favour at least to some extent the same hypothesis as Emmons. E. S. Bastin also implied the operation of supergene forces. W. L. Whitehead, on the other hand, takes strong exception to this point of view and cites many apparently excellent considerations why secondary enrichment is improbable. Among the more important are: (1) The rarity of pyrite and other sulphides and the consequent absence on oxidation of acid sulphate solutions capable of dissolving silver and from which silver under favourable conditions would be precipitated. (2) Oxidation is a very superficial phenomenon and is all post-glacial. (3) Silver deposition has not taken place along such (with broad crushed zones) fault fractures. (4) The essential barrenness and often entire absence of unoxidized veins above many rich ore-shoots.

It will be clear from preceding sections of this paper that these objections are inapplicable at the Keeley mine. Pyrite, and chalcopyrite even more so, are common minerals in all of the stronger veins, more especially Wood's vein, and increase in quantity in the unoxidized portions of that deposit towards the surface. Oxidation is not a superficial phenomenon, but is extremely pronounced in the southern portion of Wood's vein to the greatest depth yet attained, 420 ft. Certain of the less important veins of the property are also oxidized at much greater depths than could possibly be assigned to post-glacial agencies. Again, the most persistent shoots of ore in the mine occur along Wood's vein, No. 6 vein, and No. 16 vein, all of which occupy fault fractures. None of the veins of the mine is entirely barren for more than a few feet in length, though the values may be quite negligible from a commercial standpoint. It is quite true, as far as the Keeley mine is concerned, that veins may pinch out completely above rich ore-shoots, though secondary silver may have been introduced by descending solutions.

The oxidized zone in Wood's vein reaches its northernmost extension in the mine workings at a depth of about 350 ft. On the surface, the outcrop of the vein occupies a relatively deep depression filled with boulder clay, and the vein has not been exposed northward of the portion so heavily oxidized below ground. Whether oxidized material actually now occurs in this northern part of the vein or not seems unimportant as compared with the certainty that it was oxidized in harmony with the vein farther south, though not to the same extent prior to glaciation.

The very rusty character of the veinstone, showing the presence of abundant iron in the ferric condition, indicates its derivation from pyrite or some iron-bearing sulphide, such as chalcopyrite, both of which are common in the unoxidized portions of the vein.

It is easy to understand how acid ferric sulphate solutions, carrying their burden of silver leached from Wood's vein, seeped down its broad crushed zone into transverse veins below the hanging wall (such as No. 16), where under changed chemical conditions the native silver was redeposited, and, on similar reasoning, how the ore-shoots of the northern upper unoxidized portions of Wood's vein were enriched by silver derived from the leaching of still higher sections of the vein, much of which may long since have been removed by erosion.

The fact that the southern oxidized portion of Wood's vein carries considerable silver ore from the surface downward to about 250 ft. and is barren, or at least very low grade below that depth to the lowest horizon reached (420 ft.) is explained by the super-saturation of solutions with oxygen, through the oxidation of all available sulphides near the surface, and the consequent necessity of reprecipitation of at least a certain portion of the silver dissolved, in accordance with the required state of chemical equilibrium. The relatively large amount of silver in the upper oxidized portion of Wood's vein has been derived from the eroded parts of the vein, and the enriched gossan has migrated downward with the progress of weathering, following the recognized rules of surface enrichment except inasmuch as there was drastic erosion during glacial times. The barrenness of the oxidized zone in depth follows logically on the assumption that at these inferior horizons there was originally sufficient sulphide present to satisfy the requirements of such oxygen as penetrated with surface waters to these depths, and that thus an acid sulphate solution was again produced to carry the silver downward, leaving behind vein-material practically leached of all its values. It is noteworthy that the silver in the oxidized surface-enriched ore is mainly in the native form, while that in what is considered to be largely secondarily-enriched ore below the oxidized zone is chiefly argentite, ruby silver, and stromeyerite, with less conspicuous native silver, generally in the wire form. In this secondarily-enriched ore, marcasite is invariably present, and is especially conspicuous in the typical example of enrichment in No. 16 vein (420 ft.).

Dr. Bell's opinion, briefly, is that while the primary silver-bearing material, including much of the high-grade ore, either in all of the veins near the diabase-Keewatin contact, or relatively remote therefrom in Wood's vein, where structural conditions determining its deposition were present, is due to hypogene agencies, there has been widespread enrichment by descending solutions, which has materially changed the primary mineralization.

CAVING SYSTEMS OF MINING IN AMERICA

Mining and Metallurgy for January contains a paper by J. Parke Channing giving a history of the application of caving systems of mining in America since their introduction in 1882 by miners from the Furness district of Lancashire. Mr. Channing is a well-known authority on the mining of large ore-bodies both in the iron-ore regions and in the " porphyry " coppers.

The caving system of mining is that method of removing the ore from an underground body according to which the top of the ore-body is first attacked and mined out, and the capping, or roof, as the case may be, is then allowed to fall in or cave and fill the space formerly occupied by the mined ore. It is applicable, generally, to large ore-bodies where the ore is relatively soft. A factor governing the use of the system is the value of the ore itself. Admittedly, any form of caving will not extract 100% of the ore, and, of course, in the case of a very rich ore-body it is desirable to get out every pound of the ore with as little dilution as possible ; under these conditions, some other method of mining, such as that by square sets and filling, should be followed. Broadly speaking, the caving system of mining is generally used in connection with very large bodies of ore that is of low value per ton, and where open-pit mining is not possible.

Caving systems of mining may be divided into three general classes ; top slicing, sub-drift caving, and block caving. In top slicing, successive layers, usually about 10 ft. in thickness, are taken, beginning at the top of the ore and so on successively down. In sub-drift caving, the ore is taken in thicker slices ; say, for example, from 14 to 22 ft. thick, of which the lower 8 ft. is taken out with timber and the upper 6 to 14 ft. is pulled down and drawn on the retreat. The block caving system is one in which the slices are anywhere from 35 to 100 ft. in thickness, and in which the ore, after suitably breaking up, is drawn out through a multiplicity of chutes in a series of drifts at the bottom of the slice.

In attacking a new ore-body whose outline has been sufficiently determined, in the first two cases mentioned, it is frequently the practice to establish a level near the top of the ore-body, but below the deepest irregularity of the capping, and mine out the first slice by square sets. This is done with a two-fold purpose ; not only to give enough reach to the capping so that it may break and settle down, but also to establish a flat surface from which the slicing or sub-drift caving below may proceed in a regular manner. Great care must be taken in this preliminary operation, so that a cave may not occur with a sudden rush of air, with its resultant damage. This method is not always used, but has been found desirable and necessary in several of the Lake Superior hematite mines.

Sub-Drift Caving.—It is well to consider first the sub-drift caving system, as this was the first method introduced into the United States. In 1881 or 1882, George W. Wallace was in charge of the Cleveland Hematite mine near Ishpeming, Michigan. The ore-body was a soft hematite which was being mined with square sets. There came to the mine two miners from Dalton-in-Furness, Lancashire, England, who were expert in the caving method, and who explained it to Captain Wallace. He realized its good points and introduced it into the Cleveland Hematite, or old Nelson mine, as it was frequently called. It is not possible to say whether the method used there was sub-drift caving or top slicing, but Mr. Channing is inclined to think that it was sub-drift caving. Captain Wallace wrote a description of the method about 1910, but it was never published and the manuscript was lost when he moved to the west.

The first time Mr. Channing saw the sub-drift caving system was at the Brotherton mine at Wakefield, Gogebic County, Michigan, in 1886. John Pengilly was in charge of the mine, having been sent there by D. H. Bacon, who was at that time general manager of the Cleveland Iron Mining Co., and under whom Captain Wallace was mining captain at the Cleveland Hematite. The Brotherton hematite was a rather soft ore and the ore-body was of somewhat irregular shape, varying in width from 20 to 40 ft. and dipping probably at an average angle of 45°, though at times the irregular foot-wall was flat and at other times nearly vertical. The main levels were about 60 ft. apart and each lift was mined out in four successive layers of 15 ft. each. Rises were put up 50 ft. apart along the strike, and these were connected with sub-drifts, leaving in each case a 6 to 7 ft. back. Therefore, when a level was opened, these successive layers of 15 ft. were opened, with drifts along their bottom. Stoping or mining was started at the far end of the top lift, gradually drawing back toward the shaft cross-cut, timber being used for the bottom 8 ft. and the top 7 ft. being drawn or caved as retreating was continued toward the shaft.

At about the same time Guy R. Johnson adopted a similar system at the mines of the Longdale Iron Co. in Virginia. Probably soon after this a similar method was used in mining the ore-bodies in Lowmoor, Virginia. The first time that Superior men realized that this work was being done in Virginia was when the late J. E. Johnson, Sr., visited the Menominee Range in 1887-88, to examine the Chapin mine, and told them what he was doing. It shows how frequently the same problem is solved in a similar manner in different parts of the world. Since that time the sub-drift caving method has been in continuous use throughout the United States in various classes of mines, and is to-day a good standard method. The thickness of the slice removed depends entirely on circumstances. If reduced to the mere height of the regular drifts, the method is the top-slice system, and when the thickness becomes 35 or 40 ft. or over the method merges into the block-caving system.

The success of the sub-drift system depends very largely on the building up of a mat of crushed timber between the ore and the broken capping or gob. Even at the best this mat is never perfect, and when the ore from above the timbers of the extraction drift and below the mat is drawn out, waste material invariably trickles down through it and dilutes the ore. At times rushes of the gob come and some of the ore is lost. In hematite mining, where very frequently the gob is a low-grade iron ore, this dilution does not amount to much, but often in the mining of porphyry ores, where the ore may run 2% in copper and the gob only 0·2%, this dilution and loss is of importance. It is evident, however, that the thicker the slice in the sub-drift method, the less ore has to be breasted out or actually mined, and more ore is cheaply won by caving the upper part. Only the results of careful experiments and calculations can show the proper mean. There are many modifications of the sub-drift caving system, and have been described from time to time.

Top-Slice System.—In the top-slice system, haulage levels are put at any convenient distance apart, usually 100 ft. vertically. The haulage drifts themselves are sufficiently numerous, and are so spaced that rises from them can reach the top of the ore-body at points not more than 50 ft. apart from one another, the object being to avoid too much tramming to these rises in the slices. The usual thickness of one of these top slices is 10 ft., this being the distance from the bottom of the post to the top of the lagging, though sometimes the height may be only 8 ft. and at others it may be as high as 12 ft.

In taking out this top slice, various plans are used, dependent on the area of the ore-body. Frequently a system similar to the long-wall retreating method of coal mining is used, and a long face, the full width of one dimension of the ore-body, is kept constantly open. The ore is removed in a drift along this face, perhaps two sets wide ; then the further drift timber is blasted in and a new one driven back of the one left opened. This method, however, is often difficult to maintain, and a successful modification of it has been introduced. In this case the slice is divided into 250 ft. squares with a central supply rise to each square and the usual number of rises down which the ore is dumped.

In any method of this kind, hand-tramming is necessary, to transfer the ore from the place where it is broken to the rise ; this is done either by direct shovelling, by wheel-barrows, or by small cars of one-ton capacity. Endless belts and scrapers have been tried, but without success. Great care must be taken in this method of mining to ensure ventilation, as open drifts are not as numerous as in the sub-drift method. Good ventilation can be maintained, however, by a careful system of plenum and suction drifts which are not interconnected.

An interesting modification of the top-slicing method is that of making the floor of the slice inclined. This obviates to a large extent the necessity for shovelling and hand-tramming. Its use in the Coronado mine in Arizona has been described, but it is well to note that in the Coronado mine the ore-body is relatively long and narrow and it is questionable whether this method can be successfully employed in a large ore-body where it might be necessary to divide the slicing area into 250 ft. squares.

The advantage of the top-slicing system is that one has a practical control over the mining of the ore. It is in reality all breast-stoped with, of course, an increase in cost as compared with the sub-drift system, but with the advantage that nearly all the ore is removed and the admixture of waste is reduced to a minimum. In case of any unexpected caving, in which a block of ore is temporarily lost, its position can be accurately determined and a large part of it may be taken out on the next slice, either by square-setting or by drawing.

Block-Caving.—Block caving has resulted from a gradual development of some extremely crude methods of taking out pillars left from a room-and-pillar system of mining and from modifications of the sub-drift system. In the early days on the Gogebic Range it was customary to mine the ore with square sets made of round timber, the rule being a three-set room and a three-set pillar. This made the room considerably wider than the pillar, equal to the thickness of one post and two sets of lagging. The room was carried up as far as was safe, perhaps leaving one or two sets between the back of the room and the floor of the level above. Care was not always taken that rooms should be under rooms and pillars under pillars. For a rough guess, probably not over 40% of the ore was taken out in the rooms and 60% was left in the form of pillars and floors. Drifts were then driven through the middle of these pillars undercutting the ore and drawing out what would come. Probably not over half of the remaining ore was taken out before the waste came, so that the gross extraction would not exceed 70%.

In other mines, when attempts were made to increase the thickness of the slices in the sub-drift method of mining, similar losses and dilution took place. It may be said that successful block-caving systems grew out of the development of the shrinkage-stope method of mining in some of the large ore-bodies. In some cases the ore-body was divided into sections 50 ft. wide, running from one edge of the ore-body to the other, and a 25 ft. overhand stope was started in each section, the men standing on the broken ore in doing their work, the excess ore being drawn out from chutes. When it came to removing the pillars it was often found that these would not cave of their own accord, or if they did, the pieces were too large and could not be drawn out when the shrinkage ore was drawn. This led to making the thickness of the combined room and pillar less, at times as small as 25 ft., with a 10 ft. shrinkage stope and a 15 ft. pillar, or vice versa. These operated better, and finally it was discovered that it was not necessary to put up these shrinkage stopes at all. All that was necessary was to get in hand-tramming drifts sufficiently close to undercut the ore and let it drop down and then draw it out through a multiplicity of rises. In some cases this undercutting was boldly attempted without having gone through the shrinkage-stope method, and this is particularly exemplified in what is known as the Ohio method. This method is particularly noted for its economy of rising, all the rises being approximately at an angle of 45° and running off from each other like the branches of a tree. The blocks or layers drawn are about 35 ft. in thickness, and at the Ohio mine, which is a particularly low-grade mine, it was an eminently satisfactory method.

It is not particularly difficult to undercut an ore-body and break it up. The great difficulty has always been in controlling the drawing of the ore so as to prevent piping or funneling, and an undue admixture of waste with the ore. A modification of the Ohio method is employed at the Ruth mine of the Nevada Consolidated Copper Co. The ore is drawn so as to maintain a line of contact between the broken ore and the caved capping, approximating 40°.

At the Miami copper mine, in Arizona, after having gone through the experience of narrow shrinkage stopes and pillars, a block-caving system has been developed in which the blocks drawn are 75 ft. high. The main haulage levels are 150 ft. apart, so that the ore above each haulage level is taken out in two layers or blocks. From any particular haulage level the top of the ore to be drawn is 175 ft. above the floor of this haulage level. The first hand-tramming level is established 100 ft. above the haulage level, or 75 ft. below the top of the ore. Parallel hand-tramming drifts are then driven, varying from 18 to 25 ft. apart up to the boundary of the ore. Along each hand-tramming drift there are dump chutes 50 ft. apart, which are connected, by a system of vertical and inclined rises, with the drifts in the main haulage level. Along these hand-tramming drifts numerous short rises with chutes are put in, and at a somewhat higher level than the hand-tramming level, so called mining drifts are driven; each mining drift is untimbered and is halfway between the adjoining hand-tramming drifts. After these hand-tramming drifts and mining drifts are put in, holes are drilled in the sides of the mining drifts and those nearer the extremity of the ore-body are blasted, thus undercutting the ore and causing it to settle down just above the hand-tramming drifts. The broken ore from the chutes of the hand-tramming drifts is then drawn, so as to establish a plane between the capping and the broken ore, which in this case more nearly approximates 60° than the 30° or 40° mentioned for the Ruth. The ore from these rises is trammed back by hand, dumped down the nearest chute, and eventually finds its way down the main haulage level. On the general retreat, before any particular section of the hand-tramming drift is abandoned, the ore immediately on top of it is mined out in a manner similar to that of the so-called mining drifts; in this way the ore is practically drawn down to within a short distance above the hand-tramming drifts. If capping comes from any particular chute before the time determined by the engineers, it is known that piping has taken place. This particular chute is then sealed off and the surrounding chutes are drawn, which usually breaks up the pipe. The sealed chute is reopened and the clean ore usually comes after a few cars of waste are removed.

The advantage of the Miami system is that with its multiplicity of chutes the drawing of the ore is under complete control and a minimum amount of ore is lost and a minimum amount of dilution takes place. The whole ore-body is not drawn back from the boundary, but is divided into panels 150 ft. wide, leaving corresponding pillars between, so that each panel as it is drawn back is served by either six or eight hand-tramming drifts. After these panels have been drawn back a certain distance the intermediate panels are attacked, this method reducing the great pressure that would occur if an attempt were made to draw the whole face at one time.

After the 75 ft. upper block is either mined or retreated sufficiently, the next hand-tramming level 75 ft. below and 25 ft. above the haulage level is opened in a similar manner, although possibly the hand-tramming drifts may be at right angles to those in the upper block. The result is that after the two blocks 75 ft. in height have been drawn the ore is mined down to a point 25 ft. above the main haulage level. In the meantime, the haulage next level below is prepared, but before drawing out the top block on the level below it is desirable to remove the timbers from the upper haulage level so that they may not interfere with the drawing.

In comparing the above method of block-caving with straight slicing in copper mining, it may be said that the profit per cubic foot of original ore-body will be more than by straight top-slicing. The recovery of copper will not be as great per cubic foot of original ore-body as that by top-slicing, but it is more than made up for by the decreased cost. In comparing a good block-caving system with top-slicing, Mr. Channing is inclined to say that for copper ore running 2½% or over, probably it would be more desirable to use the top-slice method, but that when the ore runs 2% or under the block-caving system would be the better. One advantage of the block-caving system is that it requires only half as many miners as the top-slicing method, and, of course, requires very much less timber. If the drawing is conscientiously carried out, the results are entirely satisfactory and the loss by dilution is reduced to a minimum.

WILLIAM R. BURTON, PERKIN MEDALLIST

Sixteen years ago the late Sir William Perkin founded a medal for presentation annually to some distinguished American chemist. The last to receive this mark of honour is Dr. W. R. Burton, an oil chemist, who has been connected with the Standard Oil Company all his professional life and is famous for his discovery and development of the oil-cracking process for the production of gasoline (petrol) known by his name. We give herewith extracts from his speech of acknowledgment when the medal was handed to him on January 22.

The work done under Dr. Burton's direction which has perhaps attracted the most attention consisted in devising means for the conversion of high-boiling fractions of petroleum into low-boiling fractions in such a way as to ensure substantial yields of suitable products with a minimum loss and at a reasonable expense. The problem was to employ the fuel and gas-oil fractions boiling between 225° and 375° C., for the production of fractions boiling between 40° and 200° C. The first experiments were directed toward making a suitable product by superheating the high-boiling vapours as such, but without pressure, somewhat along the practice observed in making Pintsch gas. It was soon found, however, that this so-called "cracking" in the vapour phase required a temperature so high that the aliphatic hydrocarbons contained in the petroleum were largely converted into cyclic and aromatic bodies and fixed gases, unsuited for the purpose. The yield was poor and the quality most undesirable. Obviously the problem included the proposition of reducing the molecular weight without changing the general structure. He next tried the use of various reagents and catalysers, such as aluminium chloride and ferric oxide. Anhydrous aluminium chloride, indeed, produced some rather remarkable results. The yield and quality of naphtha products were fairly satisfactory, but there was a substantial loss of oil in the operations, and the first cost of the anhydrous aluminium chloride, as well as the difficulty in recovering it from the residues, rendered this plan unattractive.

Nearly thirty years ago Sir Boverton Redwood and Professor Dewar in England patented a pressure-distilling process for the purpose of increasing the yield of kerosene oil from the residues of Russian crude petroleum, but it never was applied industrially. It has been known, therefore, for some years that distilling petroleum under pressure served to break down the high-boiling fractions into low-boiling fractions, but, as far as could be learnt, no one had ever done it on the large scale, and, in fact, such a proposition could not commend itself to a practical refiner because of the obvious dangers from explosions and fires. But, having tried everything else that suggested itself, Dr. Burton attacked the problem of distilling petroleum in considerable quantities (8,000 to 12,000 gallons) under pressure of about five atmospheres. The first still was of a welded design, and was planned to handle 100 gallons of the high-boiling fractions. Obviously, the raw material first to be tried consisted on the so-called fuel oil, or reduced crude, meaning the residue of crude-oil after the more valuable products had been removed. He soon found that he could not work profitably with this product; when distilled with or without pressure it produced quantities of coke that deposited on the bottom of the still and caused a red-hot bottom that would not stand any rise in pressure. The next proposition comprised the use of high-boiling distillates from the crude, namely, oils boiling from 225° C. upwards. He distilled these distillates at a pressure of about five atmospheres, and was thereby able to hold down the temperature to a moderate figure, the cracking being done in the so-called liquid phase. He found to his intense gratification that the low-boiling fractions produced belonged mostly to the paraffin series, which were easily deodorized and finished into products suitable for sale. Further, the yield of saleable liquid was good and the production of fixed gases and coke was small.

Experimentally, therefore, the work was successful. But the big problem remained to be solved. Could they build large equipment that would, in a practical way, secure the desired results and at the same time be durable and reasonably free from the fire hazard that always attends operations in an oil refinery? Some of the company's practical men said it could, but more of them said it couldn't be done. In this case, however, the majority was overruled, and plans and specifications were immediately prepared for a still 8 ft. in diameter and 20 ft. long, built of ½ in. mild steel plate, which would charge 6,000 gallons of raw material. It had a safety factor of 5, the working pressure to be 100 pounds and the bursting pressure 500 pounds. The still was built and charged, with many misgivings on the part of the doubters, but with boldness and confidence exhibited by the rest. So soon as the still was hot and pressure began to develop, the first difficulty was encountered. The still was built in a workmanlike manner, and would have made a good steam boiler, but rivets and seams leaked badly under oil pressure, where they would not under steam pressure. It was difficult to induce boilermakers to caulk the leaks while the still was hot and under pressure, but men were eventually found bold enough to do it, and the first run was sufficiently encouraging to induce further experiment. But the leaks persisted until the minute portions of oil in the leaks gradually carbonized, and closed the apertures.

The experiments with the large still confirmed the results with the small one; namely, the yield of suitable gasoline (petrol) fractions was good; the loss was trifling; the cost was reasonable; and the fire hazard under close caution and supervision was not excessive. Further, it was found that the residue remaining in the still contained substantial quantities of asphaltine actually created (from a distillate containing none of it) by distillation under pressure.

Dr. Burton learned early in the work that operating at moderate pressure required a substantial dephlegmating system that would return to the still fractions boiling too high for the purpose, and allow the others to pass on.

A suitable safety valve that would operate properly with oil vapours at high temperature had to be devised. After making a number of runs with the 8 by 20 still, and in view of the fact that the demand for gasoline was increasing at a rapid rate, he asked for an appropriation of one million dollars to build sixty pressure stills 8 ft. in diameter and 30 ft. long, each charging 8,000 gallons of raw material. Considerable argument was required to convince any of the directors that such a revolutionary proposition could possibly be successful, but finally they voted in favour of it.

Dr. Burton and his co-workers had solved the big points, but there were many smaller ones. For successful results it was necessary to operate with the oil at temperatures from 370° to 400° C. in the still. At 450° C. steel begins to lose its tensile strength, and its capacity to withstand pressure. It is clear, therefore, that with this narrow margin great caution must be exercised to prevent overheating. The human element enters here, as it does in every feature of pressure-still operation, but they operated over eight years with hundreds of these stills in daily use, and manufactured millions of barrels of gasoline by this method before they had a fatal accident.

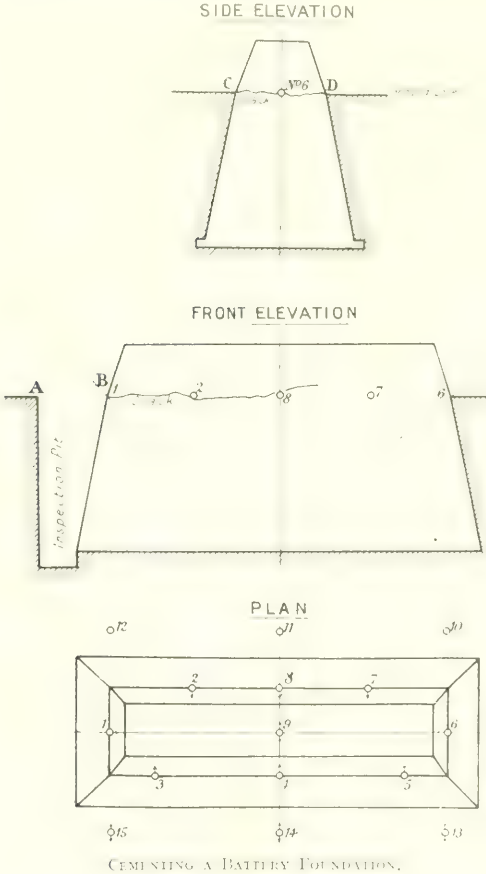
From the humble beginning of the 100-gallon still in the experimental laboratory, there is in operation to-day over eight hundred pressure stills having a gross charging capacity of eight million gallons, and licensees under the patents are operating as many more, giving a daily production of two million gallons of gasoline out of about twelve and a half million gallons total daily output in the United States and Canada. This amount of gasoline makes possible the use of two millions of motor vehicles more than could otherwise have been supplied from a given consumption of crude petroleum, and as a corollary of that proposition, and assuming 20% of gasoline as a normal average yield from crude oil, the pressure-still process is conserving for future consumption an amount of crude oil nearly equal to one hundred million barrels per year.

The consumption of gasoline by internal combustion engines during the past decade has increased at an enormous rate. In 1910 the United States consumed approximately seven hundred million gallons, while for 1920 the Bureau of Mines statistics show a total gasoline production of four thousand six hundred million gallons, of which eight hundred and fifty millions were made from natural gas, something over three thousand million gallons made by straight crude oil distillation, and seven hundred and fifty million gallons made by the cracking process. Further, statistics show that while the increase in crude oil production during the past decade has been 142%, the increase in gasoline production has been over 700%, and although some of this gasoline has been exported, the larger portion has been consumed by the ever-increasing number of automotive vehicles in America.

The increase in production of crude oil has not been commensurate with the increased demand for its products, and the pressure-still process has filled at least part of the gap. Naturally, one is inclined to speculate on what the future will be regarding an adequate supply of these important commodities. One suggestion would be that some of the large amounts of oil now being used for fuel and gas-making purposes be replaced with coal, and substantial portions of the oil used for making gasoline, the coal consumption, in turn, to be replaced in part by the further development of hydro-electric power.

The American people are notoriously wasteful in the use of natural resources with which they are so richly endowed. It is hoped the work outlined above will be considered a slight contribution toward the curtailment of such waste.

Repairing Battery Foundations.—The November *Journal* of the Chemical, Metallurgical, and Mining Society of South Africa contains a short paper by B. Schlesinger describing the application of the Francois cementation process to the repair of a faulty stamp-battery foundation.



Cementing a Battery Foundation.

When starting up a new stamp-battery in the Heidelberg district it was found after 48 hours' work that the foundation, and with it the whole of the superimposed structure, began to rock so dangerously that operations had to be suspended. An inspection pit was sunk to the underlying shale-foot at A-B (see sketch), and by washing the face of the concrete block so exposed, the writer found that a thin horizontal crack had developed at C-D, completely severing the top three feet from the lower nine feet of the block. The cause of the mishap was badly prepared and badly stamped concrete. Stones, the size of a man's fist, were seen lying loose in large cavities in the body of the foundation. For further investigation the writer had the mill re-started, with the result that portions of the concrete began dropping out of the block into the inspection pit, in much the same fashion as if the stamps were pounding on tightly packed rubble. Repairs seemed quite out of the question, and it appeared at first sight that the whole of the plant would have to be dismantled and re-erected upon an entirely new foundation, at a cost that could not be borne by the mine owners. The writer, however, decided to attempt to save the foundation by pumping pure cement into it under high pressure. He entrusted the work to the Francois Cementation Syndicate.

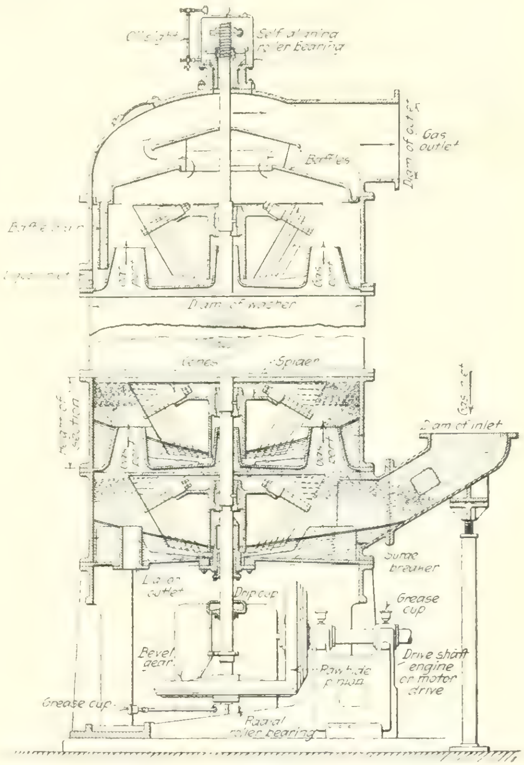
The plant employed by the Syndicate consisted of a steam-pressure pump with a 9 in. diameter steam cylinder and a 2 in. water delivery, a small wooden mixing barrel for cement, which served as an intake for the pump, and a pressure-gauge capable of registering pressure up to 10,000 lb. to the square inch. The pump was served by a boiler delivering steam at 100 lb. pressure. Nine holes of ⅞ in. diameter and 5 ft. depth were drilled into the foundation and distributed as shown in accompanying sketches. The top 9 in. of each hole were enlarged to take a 2 in. pipe 24 in. long, and screwed at one end. Such pipe was cemented into each of the holes and the cement allowed to bind overnight. The next morning hole No. 1 was connected to the delivery end of the pump, and clean water was forced through before the actual cementing operation was commenced. Thereupon a thin mixture of pure cement and water was pumped into the foundation. At first the liquid entered the concrete block without encountering any resistance whatever, and 17 bags of cement were absorbed before the pressure-gauge on the pump began to show signs of life. The indicator then gradually rose to 100 lb. and 200 lb. per square inch. Simultaneously, with the increasing pressure a tiny stream of water and cement could be observed oozing out of the thin crack previously mentioned. At this stage pumping was discontinued to allow the cement to settle, and hole No. 2 was put into commission and subjected to the same treatment as hole No. 1. After allowing a practically free passage to five bags of cement, the pressure rose rapidly to 800 lb., when pumping was stopped for 12 hours. Before ejecting the remaining seven holes, hole No. 1 was re-treated after freeing it from partially solidified cement by drilling. Two bags of cement sufficed to send the pressure up to 1,000 lb., this being considered the dangerous limit above which the block might have burst. While it required 26 bags of cement and 22 hours of work to complete the first two holes, the remaining seven holes absorbed only 15 bags of cement and 18 hours' work.

After repair of the foundation proper the writer decided, as a matter of safety, to solidify the ground surrounding the block. For this purpose six 8 ft. holes were drilled about 18 in. from the foundation, and injected in turn by a mixture of one to one cement and slimes. Some interesting phenomena could be noticed. When the pressure on the first outside hole rose to 150 lb. the gauge indicator suddenly dropped to nil, and it was found that the cement solution had broken through to the surface about ten yards from the position of the hole. One bearing-block of the line shaft, which was only 24 in. in the ground, became injected from one of the outside holes 12 ft. away. In proof of this, cement-solution forced its way 6 in. above the surface through a tiny crack in the block.

It took six days to complete the whole of the process, and 48 bags of cement were used. The total costs amounted to about £200, including the Syndicate's professional charges. After allowing ten days for the injected cement to harden, the stamps were started again. The plant has been in full operation ever since with perfectly satisfactory results.

The Feld Fume-Catcher at Ducktown.—In the *Engineering and Mining Journal* for February 4 W. F. Lamoreaux describes the investigations at the Ducktown copper smelter, Tennessee, in connection with the purification of sulphurous acid and the recovery of fume and dust. The acid is subsequently treated for the production of elemental sulphur, and the fume for the electrolytic production of zinc. The best results were obtained with the Feld scrubber. This apparatus consists of a number of separate washing chambers mounted one above the other. The ports or openings in the bottom of each chamber act as passages for the ascending gas, as well as overflows for the counter-current flow of the water or other scrubbing or absorbing liquid. The vertical shaft suspended from a self-centering, anti-friction bearing is provided in each chamber with a series of concentric frustums of cones. The number of cones varies with the size of the apparatus. The spacing between the bottom of the chamber and the bottom of the cones increases toward the shell, to provide for their equable immersion in the scrubbing liquid, as well as to secure adequate agitation to avoid deposition of solids. When the vertical shaft revolves these cones pick up or pump the scrubbing medium, which is thrown horizontally with considerable velocity through the outer perforated distributing cone. Additional impetus is given the liquid at this point by the greater rim speed of the distributor, and the liquid is projected through the gas space in the form of a fine, high-velocity spray, which, upon impact with the shell, is broken into a mist or fog. This alternating humidifying and scrubbing effect to which the gas is subjected in each chamber provides the intimacy of contact between gas and liquid necessary for the removal of finely divided insoluble matter or for the recovery of soluble constituents existent in extreme dilution, and also provides for the almost universal application of the apparatus as a scrubber as well as a reaction or absorption tower.

The effective utilization of the entire volume of scrubbing medium, as compared with the problematical contact in scrubbers of the grid type, or those in which the gas passes over wetted surfaces, can be realized by a consideration of the infinite number of smaller drops into which the normal globule is broken, as compared with the other types mentioned. A globule $\frac{1}{10}$ in. in diameter, broken up into drops having a diameter of $\frac{1}{100}$ in., would produce 1,000 of the smaller particles and would present ten times the original liquid surface to the gas stream. This increase in the amount of



THE FELD FUME-CATCHER.

surface presented per unit volume of liquid assures greater penetration and consequent absorption of the soluble vapour constituents, and, if solids are present in the gas, enables such particles to be thoroughly emulsified by the scrubbing medium. This factor is enhanced by the number of liquid contacts, or recirculations, that take place in the counter-current flow through the apparatus. The number of contacts per unit volume of liquid varies with the service, ranging from a minimum of twenty-five per minute in physical service to a maximum of three hundred per minute in some chemical services. These factors, responsible for the effective utilization of the liquid, enable the use of smaller volumes of scrubbing medium, thereby securing higher concentration of the effluent. In continuous operations, where liquid recirculation is practiced, marked economy in installation costs and power consumption is effected, owing to the smaller volumes of circulating liquid needed. The vigorous liquid agitation eliminates the possibility of internal stoppages, as has been demonstrated on scrubbers operating for several years using liquids carrying suspended, insoluble, reactive material. Any liquid entrainment is removed from the gas by means of the deflectors or baffles in the dome, and the collected liquid is returned through the drain to the top chamber.

For primary washing the Feld scrubber is ordinarily constructed with seven chambers or sections; the lower three being the washing chambers, the fourth one being a separating chamber, and the upper three being the cooling chambers. The washing is accomplished mostly in the lower sections, whereas the upper sections perform primarily the function of cooling and dehumidifying the gas, all of the functions being subject to variation at will, depending upon the amount of gas passed through the scrubber and upon the volume and temperature of the scrubbing liquid used. In the Ducktown plant the object of the scrubber is to remove the dust, but not to absorb the sulphurous acid gas. It was necessary, therefore, to conduct experiments with a view to reducing this absorption of the sulphur dioxide, and it was decided to discontinue the recirculation of the wash water, and to use only the amount of water necessary to reduce the temperature of the exit gases to the lowest attainable point, and correspondingly to permit the temperature of the outflowing wash water to rise to as high a point as permissible without incurring damage to the revolving lead cones of the washer. The results of the experiments were immediately most encouraging, and it was soon found, with added experience, that the loss of absorbed sulphur dioxide could be reduced to a negligible amount, and the cleaning effect upon the gases was almost perfect. Operating the scrubber with an outlet-water temperature of 95 to 100° C., practically no sulphur dioxide remains in the outlet water, and apparently better gas-cleaning efficiency is obtained with the hotter water; but this practice is conducive to a greater content of water vapour in the exit gas. Therefore, it was found to be more practicable to work with colder wash water, and where the loss due to absorption of sulphur dioxide might otherwise be too high, the saturated wash water was recirculated with practically no loss of sulphur dioxide.

Investigating Strata by Percussion Waves.—In British patent 20,225 of 1920 (174,095), Dr. J. W. Evans, F.R.S., of the Imperial College of Science and Technology, and W. B. Whitney describe a new method if investigating the interior of the earth's crust with the object of determining the position and nature of hidden strata without borings and thus assisting in the exploration for coal, petroleum, metalliferous deposits, etc. The method is based on the moulding and modifying influence which strata or surfaces of discontinuity in the earth's crust exert upon sound waves or like pressure vibrations which pass through them or are reflected by them.

According to a previous method of this nature, in order to investigate the interior of the earth, a sound is emitted from a suitable source and its echo or return or the sound which arrives at a distant point is observed by a receiving mechanism, and the time elapsing between the emission of the sound and the reception of the echo or between the emission of the sound and its arrival at the distant point is also measured, the sound producer and the receiver being electrically interconnected for this purpose. From the observation obtained conclusions are drawn as to the probable nature of the medium which has been traversed by the wave. The method to which the present invention relates, as distinguished from the older method, is characterized in that the sound waves, after having been modified by the medium under examination, are received simultaneously or approximately so at a number (at least two and preferably three or more) of receiving stations placed at a distance from the transmitting station.

In the accompanying figures A, B, represents the surface of the earth and C, D the stratum under examination; G represents the generating station, and R_1, R_2 receiving stations, which are suitably connected with the generating and recording stations. For the sake of simplicity only two receiving stations are shown in the diagrams. In Fig. 1 waves are generated at G and received at the receiving stations R_1, R_2 on either side of the

Fig. 1.

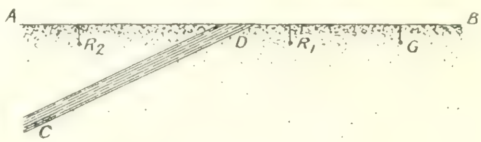


Fig. 2.

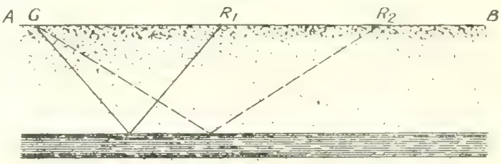
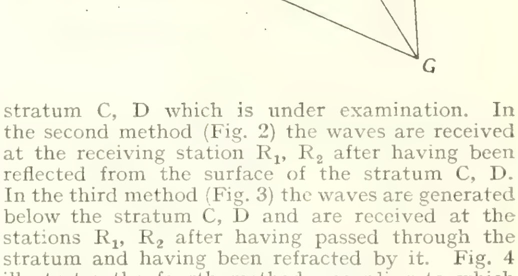


Fig. 3.



stratum C, D which is under examination. In the second method (Fig. 2) the waves are received at the receiving station R_1, R_2 after having been reflected from the surface of the stratum C, D. In the third method (Fig. 3) the waves are generated below the stratum C, D and are received at the stations R_1, R_2 after having passed through the stratum and having been refracted by it. Fig. 4 illustrates the fourth method, according to which the waves generated at G are received at R_1, R_2 after having been reflected between the stratum under examination and the surface of the earth a number of times. The distance apart of the generating and receiving stations will generally be considerable, say one mile, but may be greater or less, depending upon the nature of the earth's crust which is under examination. The receiving apparatus are preferably so placed that they lie approximately on lines radiating from the generating apparatus as centre and between 90° and 120° apart. Records of the vibrations at the generating station and at the various receiving stations are obtained, and a comparison of these records enables the observer to distinguish between the different reflections and ascertain the time intervals between them, even when they are so close together as to form composite waves. Owing to the different velocities in different media and the differences in reflection, refraction, and absorption, the nature of the vibrations recorded and the time intervals between them will enable the probable nature and position of the media under examination to be determined.

For generating the waves several means may be employed, such as vibrations generated by means of sound, explosives, blows struck by hand, or mechanical means. For receiving the vibrations the following instruments, for example, may be employed according to circumstances: Microphone, carbon, liquid, or jet; telephone receiver, in combination if necessary with automatic make-

Fig. 4.

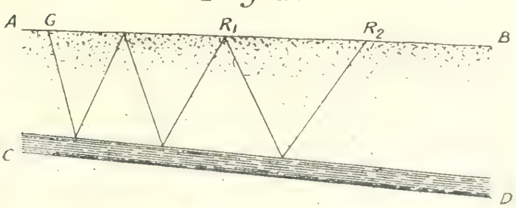
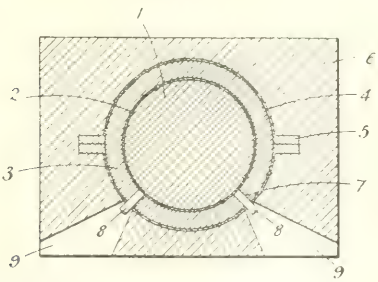


Fig. 5



and-break device such as a commutator. The following are examples of recording apparatus that may be used: Einthoven string galvanometer fitted with automatic photographic recording device; apparatus based on the piezo-electric properties of quartz, stethoscope, oscillograph, etc., in combination with automatic recording devices.

The inventors describe a specially devised receiving apparatus, which comprises essentially a casing that can be firmly embedded in the ground, a mass resiliently supported or suspended within said casing and one or more pins or the like inserted in an electrical circuit between the mass and a microphone or other apparatus whereby the relative movement between the casing and the mass, which occurs when the portion of the stratum in which the casing is fixed, and therefore the casing itself, is set in motion by the passage of a vibration from the generator while the mass owing to its inertia tends to remain fixed in space, may be detected. Instead of pins a hemispherical elastic body may be employed. The apparatus may be constructed in several forms, but the preferred form is illustrated in Fig. 5, which represents a sectional diagram of the apparatus. In Fig. 5 (1) is a solid sphere of lead enclosed in a steel casing (2). The casing (2) is surrounded by a rubber envelope (3), which is enclosed by the two hemispherical steel casings (4), having flanges (5), by means of which they are bolted together. The whole is enclosed in a concrete block (6), which is embedded in the ground. The casing (4) and rubber envelope (3) are provided with circular holes (7) in which the steel rods (8) fit loosely. The inner ends of the rods (8) are rounded to the same curvature as the sphere and press lightly against the casing (2), while the outer ends are flat and in connexion with the diaphragm or a microphone or with a piezo-electric apparatus, which is fitted in suitable openings (9) left in the concrete block, whereby slight variation in pressure may be measured.

Secondary Platinum.—*Economic Geology* for December contains a paper by G. R. Shaw, of the University of Wisconsin, detailing chemical experiments undertaken with a view to ascertain the action of platinum compounds under high temperatures and pressures, and so to explain the dissolution, migration, and redeposition of platinum. Most of the literature on the origin of platinum relates to its presence in eruptive rocks and its concentration in the more basic eruptive rocks, and comparatively little to its association with secondary minerals. The author of this paper has conducted extensive chemical research on this subject, and some of his results contained in his lengthy paper are given herewith.

The marked solubility of platinum in solutions of ferric and cupric chlorides renders the theory of platinum transportation by chloride waters entirely plausible. When heat and pressure are applied hydrochloric acid alone or even the alkali chlorides in the presence of an oxidizing agent exert a significant solvent action on the metal.

A study of the decomposition of hydrochloroplatinic acid under the influence of temperature and pressure shows it to be a most unlikely medium of transportation, decomposition being complete at 175° C. in twelve hours. Decomposition proceeds at much lower temperatures, but more slowly. The salts of this acid, the chloroplatinates, however, are much more stable compounds and are capable of existing up to about the critical temperature of water, 370°. They form, presumably, the media by which platinum is transported in chloride solution.

Hydrated platinic oxide, so easily formed by contact of the chloroplatinate solutions with carbonate rocks, is a very stable compound. Decomposition of the pure material is only apparent in twelve hours at 390°. The rate of decomposition at considerably higher temperatures is rather slow. The presence of the chlorides of sodium and calcium has little effect upon the decomposition. Magnesium chloride, however, exerts a very marked effect in lowering the point of decomposition. A similar effect is known in connexion with auric hydroxide. It has been shown that magnesium chloride solutions, when heated in a sealed tube, are hydrolysed with the formation of the oxide and hydrochloric acid. In the experimental work on platinic oxide and magnesium chloride this hydrochloric acid would dissolve the platinic oxide, forming hydrochloroplatinic acid. This is decomposed at lower temperatures than is the hydrated oxide. In this way the action of magnesium chloride can be explained. The action of manganese chloride was to appreciably decrease the rate of decomposition.

When various carbonates were added to hydrochloroplatinic acid and heated under pressure, impure hydrated platinic oxide was first precipitated upon the crystal. The action of the heat and pressure then decomposed the oxide, metal being deposited upon the crystal as a coating. In this way some excellently plated specimens were obtained. In agreement with preceding experiments, magnesite and siderite required lower temperature for reduction, while rhodochrosite required higher temperature than did calcite. The effect of contact of chloroplatinate solutions with carbonate or basic rock is at once evident. The hydrated oxide would be formed, to be subsequently reduced by some agency such as heat and pressure or reducing solutions.

The author bases the following discussion of the formation of secondary platinum deposits on the foregoing chemical results. Platinum is readily soluble in various chloride solutions, especially when heat and pressure are applied. Ferric chloride and cupric chloride dissolve platinum at atmospheric pressure, but much more rapidly at 160°. Sodium chloride and manganese dioxide, and even hydrochloric acid, are solvents at that temperature. Reduction of hydrated platinic oxide to metal under the pressure of aqueous vapour is perceptible in twelve hours at 390°. At 525° reduction is complete. The reduction proceeds in two steps, the lower oxide, PtO, being first formed. Sodium chloride and calcium chloride do not appreciably affect the temperature or speed of reduction of hydrated platinic oxide. With magnesium chloride, however, reduction to metal takes place at a temperature 80°-90° below that necessary for the reduction of the pure oxide. Manganese chloride decreases the rate of decomposition very appreciably. Reduction of hydrochloroplatinic acid solution is complete at 175° in twelve hours. Some reduction took place at a temperature of 147°. The reaction of carbonates and hydrochloroplatinic acid at high temperatures and pressures takes place in two steps. A more or less impure hydrated platinic oxide is first thrown out upon the carbonate. This is then reduced by the action of heat and the pressure of aqueous vapour to metal. The temperature of reduction varies with the carbonate used, being lowest with magnesite and siderite, and highest with rhodochrosite. Platinum is thrown out of hydrochloroplatinic acid upon serpentine and takes the fibrous form of the serpentine. Ferric chloride added to hydrochloroplatinic acid solution prevents any reduction to metal at a temperature over 100° above the point of complete decomposition of the acid alone. Solutions of sodium, calcium, and magnesium chloroplatinates are completely decomposed at a temperature of 370° in twelve hours, about that of the critical temperature of water.

Cuban Nickel-Iron Ores.—In *Chemical and Metallurgical Engineering* for February 8, C. R. Hayward gives an account of experiments on Cuban nickel-iron ores with a view to the extraction of the nickel by leaching. Hitherto these ores have been used direct in the iron blast-furnace, and the nickel goes into the steel subsequently made; but as the nickel is present in comparatively small quantities it does not add appreciably to the value of the steel. The present experiments were undertaken with a view to obtain the nickel separately and to extract it before the iron ore goes to the blast-furnace. Mr. Hayward, in his paper, tells how he found that if pyrites was added to the ore, or if SO_2 gas was introduced into the calciner or roaster, the nickel in the ore would be converted into sulphate. The ore would then be leached with water in presence of metallic iron. The leached ore would then be sent to the iron blast-furnace. The liquor obtained contains the sulphates of nickel, iron, aluminium, chromium, and manganese. To this is added calcium chloride, which converts the sulphates to chlorides and precipitates sulphate of lime, thus eliminating the sulphur. The solution of chlorides is treated with carbonate of lime, which precipitates the aluminium as hydrate. Further carbonate of lime added to the solution during aeration precipitates the iron in the solution as hydroxide. Afterwards the addition of lime converts the chlorides of nickel and manganese into hydroxides, and at the same time forms calcium chloride, which can be used over again. The nickel-manganese product may be fused to produce pig nickel, or it may be dissolved in sulphuric acid and electrolysed, giving nickel cathodes and manganese dioxide at the anodes. It is believed that this process will be commercially applicable.

SHORT NOTICES

Capell Fans.—At the meeting of the North of England Institute of Mining and Mechanical Engineers held on February 11, E. Seymour Wood read a paper describing experiments with single-inlet, duplicate, and double-inlet Capell fans.

Mechanical Handling at Mines. — *Engineering* for January 27 has an illustrated article describing the electro-pneumatic apparatus for discharging cars from cages at the shaft-mouth and controlling the action, designed by the Westinghouse Brake and Saxby Signal Co., Ltd., of London, as applied at the Thurcroft Main Colliery, Rotherham.

Thawing Frozen Gravel.—In the *Mining and Scientific Press* for February 4, E. E. Pearce describes a method of thawing frozen gravel by means of cold water.

Slime Flotation.—In the *Engineering and Mining Journal* for January 14, M. H. Thornberry gives an account of tests for floating zinc slime from ores in the Missouri-Kansas-Oklahoma district.

Smelter Chimney.—In the *Engineering and Mining Journal* for January 14, D. W. Jessup describes the building of the new Midvale smelter chimney 451 ft. high, built of brick and reinforced concrete.

Copper Refining.—In the *Engineering and Mining Journal* for January 28, C. M. Brister gives calculations for the charge in the furnace for preparing anodes from blister copper.

Bucher Cyanide Process.—*Chemical and Metallurgical Engineering* for January 18 publishes a report by M. de Kay Thompson on the Bucher process for making sodium cyanide from soda ash, carbon, and air in the presence of an iron catalyser. A brief note of this process was given in the MAGAZINE for December, 1917.

The Skinner Furnace. — The *Engineer* for February 10 gives an illustrated description of the Skinner multiple-hearth roasting furnace, which is made in this country by Head, Wrightson & Co., Ltd., Stockton-on-Tees.

Electrostatic Precipitation.—The *Journal* of the Society of Chemical Industry for February 15 contains a paper by Dr. H. J. Bush on the Lodge and Cottrell systems of precipitating fume, acid, etc., from gases.

Britannia Copper Mine, B.C.—The January *Bulletin* of the Canadian Institute of Mining and Metallurgy prints a paper by C. P. Browning describing mining methods at the Britannia copper mine on Howe Sound, near Vancouver. This mine is not now in operation for reasons already given in the MAGAZINE.

Pilgrim's Rest.—The November *Journal* of the Chemical, Metallurgical, and Mining Society of South Africa contains a paper by H. C. F. Bell entitled "Some Notes on the Pilgrim's Rest Goldfields."

Finland.—The *Engineering and Mining Journal* for January 28 contains a paper by J. J. Sederholm on the mineral resources and mining possibilities of Finland.

Magmatic Differentiation.—The *Journal of Geology* for December contains a paper by Steinar Foslie describing field observations in northern Norway bearing on magmatic differentiation.

Petroleum Seepages.—At the meeting of the Institution of Petroleum Technologists held on February 14, J. E. Hackford read a paper on the "Significance of the Interpretation of Petroleum Seepages." This paper dealt with the evidence given by seepages as to the nature of the oil that may be expected if the borings are successful.

Combating Oil-Well Fires.—At the meeting of the North Staffordshire Institute of Mining Engineers held on January 30, A. B. Clifford read a paper on the application of self-contained breathing apparatus in combating fires at oil wells, giving particulars of his experiences in 1914 in connexion with the fire at No. 4 well, Potrero del Llano, 80 miles from Tampico.

S. J. Truscott.—The *Engineering and Mining Journal* for February 4 gives an illustrated biographical notice of Professor S. J. Truscott.

RECENT PATENTS PUBLISHED

☞ *A copy of the specification of any of the patents mentioned in this column can be obtained by sending 1s. to the Patent Office, Southampton Buildings, Chancery Lane, London, W.C. 2, with a note of the number and year of the patent.*

20,225 of 1920 (174,095). Dr. J. W. EVANS and W. B. WHITNEY, London. Method of determining the position of geological strata underground by means of sound and percussion waves.

20,520 of 1920 (148,537). SPRENGLUFT GESELLSCHAFT, Charlottenburg. Improvement in blasting cartridges in which liquid air is used.

26,133 of 1920 (173,830). LUCKENBACK PROCESSES CO., San Francisco. In flotation processes, the use, as a selective and frothing reagent, of the pitch residue obtained from rosin, wood tar, or wood, particularly the pitch residue obtained in the destructive distillation of rosin.

26,358 of 1920 (174,119). H. WALKER, London. Improvements in crushing, grinding, and pulverizing mills of the ring and roll type.

27,503 of 1920 (174,402). A. BLASDALE, Ilkeston. Improved axle-bearing for mine cars.

29,691 of 1920 (174,195). J. F. NEWSON and L. G. ATTENBOROUGH, Ipoh, Perak, Federated Malay States. A dredge bucket comprising in combination a detachable lip with a flap top edge, a series of projections at right angles to this edge, and a projection inside the bucket formed by the lip rising to the rearward.

30,623 of 1920 (174,453). F. KRUPP, Essen. Counting appliance for mine-hauling plant.

NEW BOOKS, PAMPHLETS, Etc.

☞ Copies of the books, etc., mentioned below can be obtained through the Technical Bookshop of *The Mining Magazine*, 724, Salisbury House, London Wall, E.C. 2.

Mining Manual and Mining Year-Book, 1922. By WALTER R. SKINNER. Cloth, octavo, 940 pages, with many maps. Price 20s. net. London: Walter R. Skinner and *The Financial Times*.

The thirty-sixth annual issue of Skinner's Mining Manual has just been issued. This year-book is so well known that little need be said now in its praise. For the benefit of the uninitiated we may say that it is the only annual book published in England dealing with mining and kindred companies operating in all parts of the world. This year's issue covers 1,000 pages, and contains full particulars of 1,400 mining companies, gold, diamond, silver, copper, tin, iron, and coal, also exploration and mining investment companies. The particulars given of each company include the directors and other officials, date of establishment, seat of operations, description of the property, with the purchase consideration, plant erected or in course of erection, present working results, ore reserves, details of capital, calls, dividends paid, the financial position as disclosed by the latest accounts, highest and lowest prices of the shares for the last three years, and also the latest price. Lists are given of the officials connected with the companies, and comprise 3,700 directors and 935 mining and consulting engineers, their addresses and the names of the companies with which they are connected. Other useful features of the book are the supplementary index of private, dormant, or companies which have ceased to be of public or market interest; crushing tables and outputs from the principal gold mines, showing tons treated monthly, results obtained, and yield per ton and annual yields; and a dictionary of mining terms by the use of which mining developments can easily be followed. A directory of manufacturers and exporters of mining machinery is also included.

The Oil Encyclopedia. By MARCEL MITZAKIS. Cloth, octavo, 560 pages. Price 21s. net. London: Chapman & Hall, Ltd.

Deposits of Chromite in California, Oregon, Washington, and Montana. By J. S. DILLER, L. G. WESTGATE, and J. T. PARDEE. Bulletin 725A of the United States Geological Survey.

Chrome Ores in Pennsylvania, Maryland, and North Carolina. By E. B. KNOPF and J. VOLNEY LEWIS. Bulletin 725B of the United States Geological Survey.

Deposits of Manganese Ore in Montana, Utah, Oregon, and Washington. By J. T. PARDEE. Bulletin 725C of the United States Geological Survey.

Treatment of the Tungsten Ores of Boulder County, Colorado. By J. P. BONARDI and J. C. WILLIAMS. Bulletin 187 of the United States Bureau of Mines.

Sulphur and Iron Pyrites. Bulletin published by the Imperial Mineral Resources Bureau, dealing with the statistics during the war period, 1913–19. Price 1s. 6d. net.

Contact-Metamorphic Tungsten Deposits of the United States. By F. L. HESS and E. S. LARSEN.

Bulletin 725D of the United States Geological Survey.

Elements of Fractional Distillation. By C. S. ROBINSON, Assistant Professor of Chemical Engineering at the Massachusetts Institute of Technology. Cloth, octavo, 210 pages, illustrated. Price 12s. 6d. net. New York and London: McGraw-Hill Book Company.

Metallurgy of Zinc and Cadmium. By H. O. HOFMAN, Professor of Metallurgy in the Massachusetts Institute of Technology. Cloth, octavo, 340 pages, illustrated. Price 20s. net. New York and London: McGraw-Hill Book Company.

Metallography and Macrography. By L. GUILLET and A. PORTEVIN; translated by L. TAVERNER, with an introduction by Professor H. C. H. CARPENTER. Cloth, octavo, 290 pages, illustrated. Price 30s. net. London: G. Bell & Sons, Ltd.

COMPANY REPORTS

Wolhuter Gold Mines.—This company was formed in 1887 to work an outcrop mine on the central Rand to the east of Meyer and Charlton. Control was acquired by the Central Mining and Investment group on the death of Sir S. Neumann four years ago. The report for the year ended October 31 last shows that 416,103 tons was raised, and after the removal of waste, 379,400 tons, averaging 5·3 dwt. per ton, was sent to the mill. The yield of gold by amalgamation was 60,450 oz., and by cyanide 34,589 oz., making a total of 95,039 oz. The revenue from the sale of gold was £518,971, of which £119,871 accrued from premium, while the working cost was £445,015, leaving a working profit of £73,956. If it had not been for the premium, there would have been a loss of £45,915. As compared with the previous year, the yield per ton was 2s. 5d. less at the par value of gold. The ore reserve is estimated at 399,100 tons, averaging 5·6 dwt. per ton, as compared with 661,904 tons, averaging 5·7 dwt., the previous year. There is little ore left to be developed in the Main Reef Leader, Main Reef, and South Reef, and most of the ore developed during the year was in the Pyritic Reef in the western section of the mine. It is not expected that much more ore will be found in the last-named lode. The mill will depend in the future on an increasing proportion of ore from reclamation sources, and a continuous decline in the yield may be expected.

Falcon Mines.—This company was promoted by Rhodesia Consolidated in 1910 to work a gold-copper property in Rhodesia. Control has since been acquired by the Gold Fields Rhodesian Development Co. Smelting commenced in 1914. The only dividend was one paid in 1917, when 20% was distributed. There was an issue of debentures of £250,000, of which £67,963 is still outstanding. The report for the year ended June 30, 1921, shows that 184,500 tons of ore was smelted, yielding 3,139 tons of blister copper, estimated to contain 3,086 tons of fine copper, 35,960 oz. gold, and 69,685 oz. silver. The sales realized £416,735, while the working cost was £400,342. After debiting debenture interest and income tax, there resulted a loss on the year's working of £15,799. Owing to the tightness of the financial position caused by the fall in the price of copper, it has been necessary to reduce expenses as far as possible, so that development and shaft sinking have been suspended. The ore reserve is estimated at 569,000 tons, averaging 1·92% copper, 4·7 dwt. gold, and 9 dwt. silver. Falls from the walls still gives trouble, and the ore is thereby diluted in some cases, and in others rendered inaccessible for a time. Developments on the lowest level, the 12th, have proved the shoot for a length of 180 ft., averaging 33 ft. in width, and assaying 2·5% copper, 3·7 dwt. gold, and 13·6 dwt. silver. The shoot is, however, greatly disturbed and selective mining will be necessary. The report also contains details of the output for the six months to December 31 last. During this period 94,223 tons of ore was treated, yielding blister copper estimated to contain 1,551 tons of fine copper, 18,162 oz. gold, and 33,921 oz. silver. The value of the products was estimated at £181,353, and the working cost was £187,177.

Gopeng Consolidated.—This is the star company of the Wickett-Osborne-Chappel group, operating alluvial tin mines in Perak, Federated Malay States. The report for the year ended September 30 last shows that 1,429,000 cu. yd. of ground was sluiced for an extraction of 932 tons of tin concentrate, as compared with 734 tons and 837 tons during the two preceding years. The yield per yard was 1·47 lb. In addition, 12 tons of concentrate was won by tributers on the Ulu Gopeng property. The accounts show an income of £108,271 and a net profit of £54,483. The shareholders received £59,365 as dividend, being at the rate of 15%. During the year, the Sanglop estate has been acquired by the company in association with its neighbour the Kinta, with a view of avoiding future disputes as to the disposal of tailings. The prospects for the current year are good, as the working costs have been substantially reduced.

Jos Tin Area (Nigeria).—This company was formed in 1910 to work a number of alluvial tin properties in the Jos and Ropp districts, Nigeria. The report for the year ended July 31, 1921, shows that the output of tin concentrate was 185¾ tons, as compared with 143 tons the year before. The financial result of the year's working was a loss of £3,058.

Associated Northern Blocks.—This company was formed in 1899 as a subsidiary of the Associated Gold Mines of West Australia, to work the Iron Duke and other gold-mining properties situated at Kalgoorlie, West Australia. For many years satisfactory dividends were earned, but the mine is now let on tribute. In 1910 the Victorious property at Ora Banda was acquired; this is also now let on tribute. The report for the year ended September 30, 1921, shows that 5,252 tons of ore was raised by the tributers at the Iron Duke, from which gold selling for £28,224 (including premium) was extracted. The company's share was £11,855. At the Victorious the operations were seriously hampered by lack of water, and ore was raised only during the months May to September. The amount of ore treated was 8,339 tons, yielding gold selling for £14,657, of which £2,072 accrued to the company. The company received £2,300 as interest and dividends on investments. After payment of all expenses and taxes, a profit remained of £3,154, of which £2,591 has been written off for depreciation of plant. The company owns the El Refugio gold-silver property in Zacatecas. This property has been partly developed, and has been let on lease on a royalty basis. The lessee is erecting treatment plant, and milling is expected to start within a month or two.

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CONTENTS

EDITORIAL

IT is with no small regret that we announce the disappearance of the *Mining and Scientific Press* as a separate identity. With the first issue of April it merged with the *Engineering and Mining Journal* and the combined paper is published as the *Engineering and Mining Journal-Press*. Mr. J. E. Spurr is the editor in New York, and Mr. T. A. Rickard the contributing editor in San Francisco.

ATTENTION has been drawn from time to time in these columns to the special courses of lectures recently inaugurated by Mr. George Patchin at the Sir John Cass Technical Institute, Jewry Street, Aldgate. Another course is now announced. This is on Mineralogy, and will be given by Dr. W. R. Schoeller. There are to be ten lectures, each to be followed by demonstrations and laboratory work, commencing April 26.

THOSE who desire to purchase collections of Cornish ores and rocks have the opportunity of doing so now, and at the same time of helping the local Unemployment Fund. The Cornish miners are collecting specimens under the direction of Mr. E. H. Davison, of the Geological Department of the Camborne School of Mines, who classifies the specimens and arranges the collections. No. 1 collection contains thirty-two specimens of Cornish rocks, and is sold at 25s., while No. 2 consists of forty specimens of Cornish ores, and is sold for 30s.

THE thirtieth annual dinner of the Institution of Mining and Metallurgy was held at the Hotel Victoria on April 5. Mr. F. W. Harbord presided, and he was supported by a distinguished company of members and guests. The principal toasts were proposed by Mr. W. C. Bridgeman, Secretary for Mines, Sir John Cadman, Sir Thomas Holland, and Professor H. C. H. Carpenter, and acknowledged by the President, Sir Lionel Phillips, Sir Frederick W. Black, Lord Morris, and Sir James Allen. We shall give a detailed account of the speeches next month.

IN writing last month of the mineral resources of Yugo-Slavia, we stated that the celebrated Idria quicksilver mines in Carniola had been transferred from Austria to the new State. As a matter of fact, the territory including these mines has been handed over to Italy. In writing the paragraph in question we relied on Mr. D. A. Wray's report issued officially by the Department of Overseas Trade toward the end of last year. At the time Mr. Wray wrote his report it was the intention that Idria should be given to Yugo-Slavia, but between the time of writing and the public issue of the report the claims of Italy were allowed.

IN the Mining Digest particulars, tantalizingly meagre, are given of a process for treating graphitic gold ores. This process has been developed at Porcupine, and consists of treating the ore with oil before sending it to the cyanide plant. As flotation chemists are aware, carbonaceous matter is readily amenable to the action of oil, so the inference is that in the new process the graphite particles are rendered harmless by this coating of oil. Presumably the gold and the sulphides will be coated also, but, judging by the results obtained, there is no adverse effect on the power of the cyanide to dissolve the gold. A question of this sort arises when flotation concentrate is cyanided, but the trouble then comes usually from the presence of deleterious minerals in the concentrate rather than from the oil. The oil is generally soluble in the cyanide or the alkali used in the process, so that if the concentrate is cyanided raw there may be no evil result. If, however, the concentrate is roasted the oil may not be entirely removed, but may be partly transformed into carbonaceous matter, which will interfere with cyaniding. Thus it has been found that concentrating graphitic ores by flotation does not give good results. It was a most interesting step on the part of the Porcupine metallurgist to oil the pulp with a flotation oil, but not to obtain a flotation concentrate, sending the pulp instead direct to the ordinary cyanide plant. By a remarkable coincidence, the mail which brought the Bulletin of the Canadian Institute containing this paper brought also a communication from the Merrill Company, of San Francisco, in which they announced their acquisition of a similar process invented by Mr. Silver, metallurgist to the Tonopah Belmont Development Company. This communication does not give any details, but merely states that by a simple pre-treatment of the ore with an inexpensive reagent the carbon is rendered inert and the ore may be cyanided with normal extraction and cyanide consumption. Further particulars of this process are anxiously awaited. In all probability the explanation of the action of the reagents at Porcupine and in the Silver process is provided by the adsorption theory, the adsorption action on the carbon surface being greater than that on the gold surface. We believe that suggestions were made some years ago by both Mr. A. W. Allen and Mr. R. T. Hancock that the graphite difficulty might be solved in this way, but at the time no metallurgist cared to undertake a research for the requisite reagent.

WE publish this month a further contribution by Dr. J. Morrow Campbell to the discussion of the origin of minerals and ores, dealing particularly with the function of water in this connexion. As usual he gives his readers plenty to think about, and his collection of facts and arguments will be appreciated even by those who differ from him in some phases of his views. To us, individually, his most interesting point is that cassiterite may be carried by and deposited from comparatively cool water. He might go further and attribute surface enrichment of cassiterite to transmigration and redeposition through the agency of water. It is difficult to explain the existence of large cassiterite crystals on and near the surface in any other way. The oft-discredited theory of the growth of cassiterite in the Red River receives support from such a supposition. It is known that some of the best extractions are made near the sea rather than immediately below Tuckingmill, and this can be explained by the theory that the finest slime is dissolved and redeposited on the coarser slime, so that the particles are made large enough to be caught on the buddles. This dissolution and building up can be shown in the laboratory with readily soluble crystals, such as alum, and there is no reason why the same process should not occur with a substance that is soluble with extreme difficulty. Reverting to Dr. Campbell's paper, many of his facts and reactions seem to go to show that much rock and ore formation can be ascribed to surface or shallow influences instead of to deep-seated igneous action, so that magmatic theories once more receive something in the way of a rebuff. It is possible, however, that we have not strictly interpreted Dr. Campbell's suggestions and views as he would have us do; but, in any case, we trust he will continue his study of the geochemical functions of water.

The Production of Gold in 1921

Of recent years it has become increasingly difficult to make anything like an accurate estimate of the world's output of gold, and most of the newspapers and journals that used to make inquiries and reports are now rather shy of the subject. The *Engineering and Mining Journal* no longer gives its provisional estimate early in January. In this country the *Statist* still continues its estimate, but some of its figures are open to question; for instance, it gives 690,000 oz. as the Canadian output, as against the official report of 924,374 oz., and less even than the Porcupine output of 707,509 oz. The Imperial Mineral Resources Bureau is doing excellent work in collecting statistics of output, though it does not attempt to issue early estimates of output, and eventually it will be desirable to rely on its reports, for its opportunities for collecting figures are unrivalled. The calculation of returns is made more difficult nowadays by the gold premium, for in many cases it is not clear whether the money value is at par or includes the premium, and, if the latter, the amount of premium is uncertain. It is necessary to reiterate our oft-expressed desire that all figures for gold output should be in fine ounces. We have no intention of submitting an estimate. Such figures as are obtainable are published in our pages as they arrive, and in this way we have given those for the Transvaal, Rhodesia, India, Canada, Queensland, Victoria, West Australia, and New South Wales. We have not received figures for other parts of Australia, nor for New Zealand, the United States, Mexico, Central America, South America, China, Japan, Corea, Siberia, Europe, Dutch East Indies, Malay Peninsula, Congo, or Madagascar. When further returns come in, we may attempt an estimate of the world's yield. Our general impression is that the output has been maintained in a satisfactory manner considering the many disadvantageous conditions as regards cost of supplies and labour. Of course, the premium obtainable has helped immensely in most parts of the world. Irrespective of questions of cost and premium, many mining centres have been working during recent years under the shadow of a knowledge of an approaching exhaustion of the ore-bodies, but the fall during 1921 from this cause has not been very marked, and in many cases it has been an example of threatened men living long.

Ontario and Manitoba

At the present time the only mining country of the world to afford promoters the chance for even a small boom is Canada. Reference is continually being made in these columns to the developments and opportunities at Porcupine and Kirkland Lake, and in this issue further reference is made to a new venture at Porcupine; while all available information has been given also relating to The Pas district in Northern Manitoba. Public attention was drawn a year or two ago to the latter district by the acquisition of the Flin-Flon copper deposit by the Mining Corporation of Canada. More recently gold claims at Herb Lake and Elbow Lake have done so well as to attract a flow of prospectors. The Murray claims at Elbow Lake have been acquired by the Hollinger Company, of Porcupine, and are reported to be giving encouraging results. Several properties at Herb Lake are of promise, but require further development. One of these, the Bingo, is being brought to the attention of English financiers. At this property a shaft is down 170 ft. on a narrow but rich vein, and Mr. J. S. De Lury, who is known to our readers as a competent mining geologist, speaks favourably of the prospects. The only thing against the scheme of purchase and provision of working capital is that the capitalization and vendors' consideration are far too high.

In view of the attractiveness of these Manitoba discoveries, we have quoted in the Mining Digest in this issue from a paper by Mr. J. P. Gordon, read at the March meeting of the Canadian Institute of Mining and Metallurgy. Mr. Gordon gives an outline of the present knowledge of gold occurrences in The Pas district. It will be seen from his remarks that gold is found both associated with big copper deposits and in native form or associated with small amounts of sulphides. The copper deposits include the Flin-Flon, but it is with the latter occurrences that we are concerned at present. In the Herb Lake district the Rex property has done well and promises to become a regular producer when adequately developed and equipped. A number of other claims are mentioned by Mr. Gordon, among which is the Bingo. At these properties the gold is found in quartz lodes containing varying amounts of pyrites. In Mr. Gordon's opinion, however, more important than the Herb Lake section is the Elbow Lake area, where, as has been already mentioned, the Murray claims are being developed by the Hollinger Company. It is believed that both Elbow Lake and Herb Lake districts will repay investigation, and information indicating the extent of the deposits now being tested is anxiously awaited. Until more development work has been done, anything like unqualified enthusiasm is not warranted.

Burma Corporation Metallurgy

As we mentioned in the December issue, Mr. E. P. Mathewson has been in Burma with a view of studying the metallurgical problem at the Bawdwin lead-zinc-silver-copper mines of the Burma Corporation. Mr. Mathewson is, of course, well known in mining circles, but his name has not penetrated far into the London commercial world. It is advisable therefore to say here that he is a Canadian by birth and education, and that he has been high in the councils of both the Anaconda copper group and the Guggenheims. Thus he is intimately acquainted with the technology of copper and lead, and with the business aspects of their production. We can therefore confidently accept his advice in connexion with a great scheme like that of the Burma Corporation, believing that he can indicate the way of obtaining the biggest profit at the least capital outlay. The report embodying his views and recommendations was circulated last month in London, and it contains much valuable advice, both as to general policy and in regard to details of practice.

During recent years we have given particulars of a number of reports by engineers and metallurgists on the concentration and smelting of the Burma ores, particularly those of Mr. Laurence Addicks and Mr. R. G. Hall. In addition it will be remembered that Mr. J. A. Agnew wrote an excellent summary of the position and prospects when the National Mining Corporation undertook the placing of additional capital in the summer of 1920. The plan at that time was to build an entirely new smelter, to develop coal mines, and to go into partnership with Tata & Sons and the Indian Government in connexion with the erection of a zinc smelter near the Tata iron and steel works in India. There was also an intention of applying the Elmore hydrochloric-acid process for separating lead and zinc to the treatment of middlings. Since then the metal position of the world has changed in a serious way, the Tata zinc scheme has been held-up, and the scarcity of suitable labour in Burma has become a limiting factor in any policy of expansion of operations. The directors have in consequence recognized the inadvisability of proceeding with the building of a new metallurgical works. Hence their desire to have Mr. Mathewson's advice on the situation.

In his report Mr. Mathewson begins by discussing the labour situation, and he entirely confirms Sir Trevredyn Wynne's statement at the meeting of shareholders, which was reported in our February issue. He is of opinion that the treatment of the coolies has not been ideal. For instance, the shift-bosses under whom they work rarely know the languages of the coolies, and do not understand their accustomed requirements as regards food and amusements. Thus there has been an element of discontent which has militated against the formation of a permanent colony. Also the discharge of smelter fumes into the air has caused much physical discomfort, for the gases and dust are entrapped in the mists and give rise to various irritations and even to lead poisoning. The remedy lies in the erection of a bag-house. The old sintering plant which involved dry crushing of the sinter added to the discomfort of the men, and this is to be remedied by the more general adoption of the Dwight-Lloyd plant. Mr. Mathewson proceeds to discuss the railway accommodation, and shows that this is at present too limited to enable the mine and smelter to be worked at full capacity. Arrangements are now in hand for the increase of the delivery of ore from the mine to the smelter from 600 tons to 700 tons per day. As regards the mine, Mr. Mathewson expresses his satisfaction with the methods of development and mining at Bawdwin, and shows that the regular delivery of 700 tons of ore per day depends solely on the supply of labour.

Naturally, the chief interest of his report centres on the concentration and smelting problems. All attempts to separate the lead and zinc sulphides mechanically have failed from the economic point of view. By water-methods it is possible to obtain a zinc product averaging 45% zinc, 11% lead, and 16 oz. silver, but the cost of operating the dressing plant on these lines would be prohibitive, and moreover the present commercial value of such a product when shipped to Europe would be *nil*. As regards separation of the sulphides by selective flotation, no reagent has yet been discovered that will act satisfactorily. As, however, it is reported that a separation has been effected on a Mexican ore of similar composition, investigations have not yet been entirely abandoned. At the present time it is clear that the zinc in the ore cannot be reckoned as an asset, and all that can be recommended is that the zinc content shall be reduced as far as possible, as the less zinc there is in the lead concentrate sent to the blast-furnace the cheaper and more rapid is the smelting operation.

Reference has already been made to the discharge of smelter fumes into the atmosphere. This is also a cause of great loss of lead and silver, and by Mr. Mathewson's advice a bag-house is to be erected to serve the double purpose of saving metals and of preventing physical discomfort to the community. As regard smelting practice generally, he recommends the provision of another blast-furnace. This will be necessary if the daily output of the mine is to be kept at 700 tons. It will also assist in the study of slags, a study which has not been adequately pursued in the past, with the result that considerable lead and silver are lost. The furnace can also be used for the removal of lead and silver from copper matte, which has hitherto been allowed to accumulate. Another product that has been accumulating is nickel speiss, containing nickel, lead, and silver. Mr. Mathewson gives hints as to the ways and means of selling this product. One of his important points is that all the metallurgical operations shall be in future controlled pyrometrically, thus saving fuel and conserving apparatus and increasing the extraction.

Mr. Mathewson concludes his report by suggesting that more ore should be smelted direct and the amount of concentration work thereby reduced. He is of opinion that all ore averaging 35% lead or over might be treated direct, and that the concentration of the milling ore should be confined to the removal of as much zinc as is economically possible. Finally, he deprecates the application of any new processes in Burma at present, for the main problems require all the attention of the metallurgists, and there is not a sufficiency of the requisite intelligent labour. So the Elmore process will have to stand on one side for the time. Altogether, Mr. Mathewson's report reveals the master hand; it will be well for the Corporation to follow his advice.

REVIEW OF MINING

Introductory.—The threatened stoppage in engineering works in this country has come to pass, owing to the men not accepting the masters' terms, but it is clear that reduction in costs will be necessary if new orders are to be obtained, and probably a resumption will not be long postponed. The prices of metals continue low. More copper mines in America have started again. The Rand strike is over. There is a general strike in the United States among the coal miners.

Transvaal.—The Transvaal gold industry has passed through a very severe crisis since our last issue was published, but thanks to the prompt action of General Smuts the tension was relieved almost at once. As mentioned last month, the strikers had got out of hand, and many acts of violence were committed. Whether these acts of rebellion were prompted by European agitators or not is open to question, but there is a general feeling that they were. General Smuts took military steps without delay and soon repressed the insurrection, capturing many prisoners. Affairs are now quieter on the Rand, and business is gradually resuming its usual proportions. The mines are operating once more, but as one-third of the natives had been repatriated it will be some time before the output regains normality. The white workers are going back on terms favourable to a reduction of costs, but the whole question of the domination of the men's unions will have to come up for discussion.

The way was made clear for the action of General Smuts and Parliament by the issue of an admirably expressed statement of their case by the Transvaal Chamber of Mines. In temperate language this statement showed how costs had been steadily advancing during recent years, owing to the Industrial Federation insisting on high wages and the employment of more white supervisors than were actually necessary. The Chamber considers that 2,000 white men should be gradually retrenched, for they are redundant to that extent. The statement also contained details of costs per ounce of gold won, and thus conveyed a clear idea as to how many mines could make ends meet with different prices of gold. No less than twenty-two out of the thirty-nine mines would have to close if gold went back to par without any reduction of costs, a tragedy for the workers and also for the community in general. The arguments put forward by the Chamber impressed the substantial men of Dutch descent, so that Parliament was of one mind when the outrages commenced. As regards damage done to the mines, this was happily reduced to a minimum owing to General Smuts' rapid movements, but there are many cold-blooded murders to deplore.

Rhodesia.—The output of gold during February is reported at 51,422 oz., as compared with 53,541 oz. in January and 40,816 oz. in February, 1921. Other outputs in Southern Rhodesia during February were : Silver, 14,404 oz. ; coal, 36,521 tons ; copper, 284 tons ; asbestos, 380 tons ; arsenic, 46 tons ; mica, 1 ton ; diamonds, 10 carats.

West Africa.—The Taquah and Abosso companies report that supplies of labour are gradually increasing, so that both output and development are now in a more satisfactory position.

Tanganyika.—Attention is being paid to the coal and oil possibilities in this territory, late German East Africa. It is generally held by geologists that the whole of the east coast of Africa from the Limpopo northward provides chances for oil exploration. The rocks are favourable, and a comprehensive scheme of structural investigation and boring may be undertaken one of these days.

Soudan.—It will be remembered that rather over a year ago Tanganyika Concessions formed the Nile-Congo Divide Syndicate for the purpose of sending Major Christy to explore for metals and minerals in the southern Soudan. Reports are now to hand of the discovery of alluvial gold in the headwaters of several tributaries of the Nile, and of an outcrop of auriferous copper ore. Further details are expected at the forthcoming meeting of Tanganyika Concessions.

Australia.—Owing to the reduced production of lead concentrate at the Central mine, Broken Hill, the Sulphide Corporation has suspended smelting at the works at Cockle Creek, near Newcastle, and the concentrate is now being treated at Port Pirie by the Broken Hill Associated Smelters.

The Mount Morgan company announces a resumption of underground operations on March 15, consequent on the agreement on the labour question mentioned in our last issue. The concentration and metallurgical plant started on March 20.

The following table gives the official figures for the output of metals and minerals in Australia during 1921.

Lead :	Metal in Concentrates produced, tons . . .	83,878
	Smelter production, tons .	55,749
	Metal in Concentrates Exported, tons . . .	6,448
Zinc :	Metal in Concentrates produced, tons . . .	139,460
	Smelter production, tons .	1,681
	Metal in Concentrates Exported, tons . . .	19,616
Silver :	Metal in Concentrates produced, oz. . . .	8,326,006
	Refined Metal produced, oz. .	4,572,878
	Metal in Concentrates Exported, oz. . . .	726,121
Copper :	Electrolytic and Refined, tons	18,600
Tin :	Refined Tin, tons . .	2,985
Iron :	Pig Iron, tons . . .	352,365
Arsenic, tons		978
Coal, tons		12,788,191
Gold, oz.		755,000

New Zealand.—At the Waihi Grand Junction gold mine the mill has been shut down owing to there being insufficient ore to keep it going at full capacity, and work is now being concentrated on development. At the Waihi mine a fire broke out last month in old workings on the Edward lode, and the output of ore has been necessarily reduced; but it is believed that the effects will not be serious.

India.—The official return of output of gold in India during 1921 gives 432,647 oz., of which 390,549 oz. came from the Mysore group of mines worked by John Taylor and Sons' companies.

Developments in depth at the Balaghat gold mine continue to be encouraging. The latest report states that at the 4,390 ft. level assays are being obtained averaging 22 dwt. to 29 dwt. over a width of 6 ft.

Malaya.—Elsewhere are given particulars of the progress of the Kamunting Tin Dredging Company and the arrangements made for the purchase of Ipoh's second dredge and part of that company's ground. At the meeting of shareholders it was announced that some of the funds required for this purpose were to be obtained by surrendering the policy which provided for the repayment of the original capital of the company in fifteen years. The surrender value of the policy will amount to nearly the sum of the premiums already paid, about £30,000, and the company will be freed from having to provide over £6,000 per year in future. Of course, it is to be regretted that this interesting experiment in amortization is not to be continued, but on the other hand it is better to use this money than to raise capital at times like the present for the new venture.

Canada.—The official returns for the gold output during 1921 give 924,374 oz., of which 707,509 oz. came from Porcupine.

We deal in the Editorial columns with the mining activities in Ontario and Manitoba. With regard to the latter district, it is interesting to note that Mr. J. P. Gordon, the writer of the paper quoted, has developed a promising gold property on Copper Lake and that he has granted an option on it to the Nipissing company, of Cobalt.

On April 3 a meeting was held in London of the English shareholders in the Mining Corporation of Canada to hear an address by the president, Mr. J. P. Watson. With regard to the company's Cobalt interests he mentioned that the recent purchase of the Buffalo mine had revived their activity in this centre, but that their mines generally were gradually becoming exhausted. The company is expecting good results from the Haileybury-Frontier claims at South Lorrain. This property had previously been chiefly worked for cobalt, and the owners parted with it owing to the contents of this metal decreasing in depth, where silver becomes continuously of greater importance. Mr. Watson, in his speech, said much about the Flin-Flon copper property in Manitoba. Here the assured ore is estimated at 16,000,000 tons, and the drill cores indicate an average assay of 1·82% copper, $1·60 gold, and 1·16 oz. silver. In course of shaft-sinking and cross-cutting, a body of ore much higher in copper was discovered, and the engineers now estimate the average copper content of the assured ore at 2·4%. As regards the company's two ventures in British Columbia, these have failed to give satisfactory results and have been abandoned.

Many references have been made in these pages to the Davidson mine at Porcupine during the past two years or so. This property has been introduced in London this month, the shares offered being in the Porcupine Davidson Gold Mines, Ltd., a company registered in Ontario, with a capital of £1,000,000. The purchase price is £675,000, of which £625,000 is in shares and £50,000 in cash. The promoters are Mitchelson Partners, Ltd., and reports have been made by Mr. Rowland C. Feilding, Mr. Frank C. Loring, and Mr. George E. Bent. Mr. Feilding estimates the reserves in the five levels at 350,000 tons, averaging 11 dwt. per ton, and the mill is to treat 175,000 tons per year. It is not clear from the prospectus how much of this ore is actually proved. Mr. Bent reports that exploration has been continued by diamond-drill from the surface and from the 600 ft. level and that the results indicate a satisfactory continuation of the ore. The prospectus offers 800,000 5s. shares at par. Our remarks elsewhere in this issue concerning over-capitalization are applicable to the case of this company. Moreover, the statements in the prospectus as to mining prospects are not quite as clear as we might desire.

The financial tangle which caused the temporary collapse of the operations of the North-West Corporation at Klondyke are being unravelled, and a new company, called the New North-West Corporation, has been formed in Canada to acquire the properties of the English corporation, a dredge belonging to the Canadian Klondyke Mining Co., and shares in the Canadian Klondyke Power Co. Additional capital is being subscribed for the purpose of acquiring other dredges, thawing plant, etc. It will be remembered that the Granville Mining Co. is a large shareholder in the three old companies above named, so will be proportionately interested in the new one.. The Consolidated Gold Fields of South Africa represents the Canadian company here, and has issued some information regarding the campaign during 1922. From this it appears that two dredges will be at work, one on Dominion Flat and one on Granville Flat. The gravel on the former flat is reported to average 49 cents per yard and on the latter 38 cents. Fuller details of this reorganized enterprise are expected shortly.

United States.—The latest copper mines to resume operations are the Nevada Consolidated, Ray, and Chino, of the Jackling group. The Phelps Dodge Corporation announce that the electrolytic refining of the copper produced at its smelters will in future be done by the American Smelting and Refining Co. at its Perth Amboy works, instead of at the Nichols Chemical Company's works at Laurel Hill, Long Island.

Nicaragua.—It will have been noticed that the shares of the Corderoy Syndicate have been introduced on the London market. This syndicate has recently acquired three groups of gold mining properties in the central mountain range of Nicaragua, which are connected by rail with the Port of Corinto on the Pacific coast. These properties have been worked previously, and are partially developed and equipped. The mining men connected with the venture are Messrs. C. H. Hills and R. C. N. Robinson and Dr. T. R. Marshall, while reports have been made by Messrs. J. A. Gilmour, E. W. J. Edwards, and J. V. Lake.

Colombia.—A meeting of shareholders in the Colombian Mining & Exploration Co. was held March 17 to receive an account by Mr. E. L. Heinemann, one of the directors, of his visit to the property. Mr. Heinemann stated that the new mill is about ready to start, but that the Marmato ore available for treatment is not expected to go over 7 dwt. per ton. He also expressed some dissatisfaction with the nature and quality of the ore and the lack of systematic development. He had recommended that the company should acquire the Echienda mine, which is wedged into the Marmato property, from Mr. Norman C. Jenks, the company's former manager, who is now working the property. Reports indicated that the ore now being disclosed at the Echienda is of higher value than that at Marmato. The company accepted Mr. Heinemann's suggestion and has entered into a contract to purchase the Echienda property, hoping thereby to be able to report the treatment of ore of average higher grade when the mill starts.

Argentine.—The Great Boulder and Bullfinch companies have recently been turning their attention to other countries than West Australia. It is now announced that they are jointly sending engineers to the Argentine to examine gold deposits at Sierra de las Minas, in Rioja Province. A company called the Boulder Exploration Syndicate has been formed for the purpose of carrying on this business.

Portugal.—The position of Mason & Barry has greatly improved lately, and the directors have been able to recommend a dividend and bonus for 1921 amounting together to 50%. This company was hit harder during the war than most of the pyrites producers in the south of the Iberian peninsula, and its recovery is therefore highly gratifying. On the other hand, conditions in the pyrites mines over the border in Spain are still adverse, and both Rio Tinto and Tharsis find it inadvisable to distribute dividends for 1921.

JAMAICA

ITS GEOLOGY AND MINING POSSIBILITIES

By SIR STOPFORD BRUNTON, Bart.

The author revives interest in a British Possession that is not at present a producer of minerals or metals. He quotes the old Survey report of fifty years ago, and gives some of his own observations.

INTRODUCTION.—The British West Indies form a portion of the Empire which for centuries remained comparatively unknown, but which during recent years has become more prominent. Therefore some information about one of these islands may be of interest at the present time.

Shortly after demobilization I made a trip through Cuba to Jamaica, and I propose to set forth in this article some results of my own observations, together with some correlated information from the report of the Geological Survey of Great Britain on Jamaica published in 1869.

The British West India Islands, of which Jamaica is the largest, have so far not attracted much attention from the point of view of mineral development. Two reports were issued by the Geological Survey of Great Britain, one on Trinidad and the other on Jamaica, in 1860 and 1869 respectively. The British geologists in Jamaica reported indications of all sorts of minerals, both precious and base, but as the survey was undertaken at a time when the science of geology as applied to mining was very little understood, the significance of all these indications was not properly appreciated. Great credit is due to these geologists for careful and accurate work. Unfortunately Mr. Lucas Barrett, who had charge of the work of correlating the reports, was drowned while working in a diving bell in the harbour at Kingston, and the whole report is therefore not as consecutive as it might be, and loses some of its merit, albeit through no fault of the workers.

The adjacent island of Cuba, under the supervision of the United States, has within the last twenty years developed enormous mineral resources; iron, copper, gold, and manganese. The geological relationships of Jamaica are similar to those of Cuba and offer the same possibilities for mineral deposition. The possibilities for mining locations are only fewer than those in Cuba because the island is smaller. In view of these circumstances it would seem reasonable that operations for the development of the mineral resources of the island might be undertaken, which, if conducted along scientific and conservative lines, might result in profit to the individual investor as well as benefit to the Empire.

GEOGRAPHICAL POSITION. — Jamaica is situated in the Caribbean Sea (latitude 17° 40′–18° 30′, longitude 76°–78° 30′). The length in an east-westerly direction is about 150 miles, and the width in a north-southerly direction varies from 30 to 50 miles. The eastern part of Jamaica is mountainous, comprising a chain of peaks (known as the Blue Mountains), the highest of which rise to 7,500 ft. The sides are very steep and deeply serrated, precipices as high as 200 ft. sheer being found near the summits. No one inhabits this part of the country. Round the base of these mountains there is a low coastal plain, which is fertile, well populated, and cultivated for bananas, coco-nuts, etc. The western part is much lower and more uniform in elevation than the east, the average height of the hills being only about 1,500 ft. The greater part of the western end is covered by a soluble limestone through which the water drains until it reaches the harder rocks below, instead of running off on the surface of the limestone. The result of this is that some rivers will flow along the surface and then suddenly disappear underground, while in other places a large river will suddenly appear from a hole in the ground. In addition a certain district in the north-western part of the island is almost impassable owing to the surface being eroded into what are technically known as "sink-holes," large pits about 50 ft. deep and a couple of hundred feet across the top. This region is known as the "Cockpit" country. The rest of the island is fertile, and the scenery is beautiful. The whole of the habitable portion of the island is thickly populated, some of the land being held as large estates, while other districts are in the hands of small settlers.

HISTORY AND LAWS.—Jamaica was discovered by Columbus, and was occupied by the Spaniards in 1494; it was captured by the British about 160 years later. The original inhabitants died out during the

Spanish occupation, and negro slaves were introduced from West Africa by the Spaniards. This state of affairs lasted until 1832, when the slaves were given their freedom. The island was treated by Cromwell as a conquered possession, but was afterwards granted the rights of a "settled" colony.

The mining situation in Jamaica is peculiar. No mining has been carried on for many years, with the result that no definite mining laws have ever been formulated specifically for the island itself. The common law of England holds good in a general way, with modifications to suit the particular case. Several old laws have been omitted from the Statute Book as being obsolete, but never having been repealed they are apparently still in force. The mining rights for gold and silver are reserved to the Crown; base metals are the property of the subject on whose land they are found.

Several mining enterprises have at one time or another been undertaken by private capital; but as these have always failed, either through insufficient knowledge or by too extravagant development, the residents in the island are at the present time in no way interested in mining concerns or operations. Enough has been done, however, to keep a certain amount of interest alive.

CLIMATE.—Although Jamaica lies in the Tropics, the climate is very good. The mean daily heat at sea-level may be assumed at 80°, and a noteworthy fact is that sunstroke is almost unknown. Round the coast it is warm and tropical, with such fruits as bananas, pineapples, etc., and a luxurious vegetation; but as one ascends the mountains the climate becomes more and more temperate, so that at about 5,000 ft. one finds strawberries and such like northern plants, while snow has been known to lie on the top of Blue Mountain peak. There are two principal rainy seasons, namely May and October, but there is usually more or less rain all through the summer months. The island is subject to earthquake shocks, and during the summer months it is sometimes visited by cyclones, which come about once in three years.

LABOUR.—As before-mentioned, the original inhabitants died out during the Spanish occupation, and were replaced by negroes from the West Coast of Africa. These negroes were emancipated from slavery in 1832. There is in Jamaica no distinct "colour line" as there is in some of the other islands and in the Southern States.

The census in 1911 showed the population as follows:—

White	15,605
Coloured	163,201
Black	630,181
East Indians	17,380
Chinese	2,111
Colour not stated	2,095
	831,383

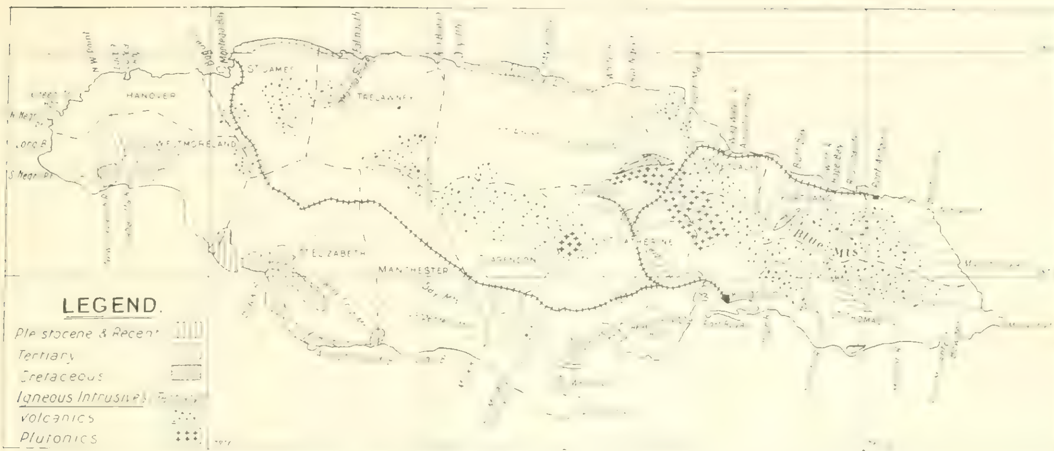
From this it will be seen that the greatest source of labour is coloured or black; cheap as regards pay, but not skilled or very strenuous. The only information that I had about pay was that a land surveyor told me he paid his men 3s. per day.

COMMUNICATIONS.—The internal communications consist of a Government railway from Kingston to Port Antonio and Montego Bay, with branches to Ewarton and Chapleton; the total length being 197½ miles. Besides this, there are very good roads over all parts of the island, with the exceptions of the mountainous country in the east, and the "Cockpit" country in the north-west. The roads are well built and have a good bed of crushed limestone pebbles, so that they stand even the wear and tear of motor traffic, which has lately developed to a considerable extent. They are mostly confined to the lower lands and river valleys, where the grades are easier, but they traverse the central range in two or three places by passes or gaps.

There are no lakes, and the rivers are so rapid that they are totally unnavigable.

The external communications are as follows: The Port of Kingston lies distant 4,238 miles from London, 3,996 from Avonmouth, 1,795 from Halifax, N.S., and 1,457 from New York; or, reckoned in time of freight boats about fourteen days from England, nine days from Canada, and seven days from New York. The Canadian Government has just commenced a service of freight boats from Canada. There are three or four good harbours; Kingston and Port Morant on the south side and Port Antonio on the north will all shelter boats of 5,000–6,000 tons and probably larger ones.

POWER.—There is a certain amount of water power to be obtained from the rivers. I would estimate the minimum supply of the Rio Grande at about 300,000 cubic feet per minute, and the fall sufficient to be utilized for the production of power. Other



Map of Jamaica, showing the Main Geological Features.

rivers such as the White River could be utilized in the same way. The volume of the rivers is, however, very variable, owing to their torrential nature, due to the steepness of the mountain sides and absence of any lakes.

There is no coal in the island, so far as it at present known, but the presence of "carbonaceous matter," resembling true coal is reported in very small quantities from the district of Hanover; and some lignites are found in the districts of Portland, Manchester, and Trelawney, analyses of which has been made by the Imperial Institute, London. The prospects of finding any commercial deposit of coal are poor.

So far, neither petroleum nor natural gas has been found in Jamaica, but during the winter of 1919–20 some prospecting was done with a view to determining the possibilities of finding oil in certain western parishes.

Timber.—The following extract is taken from *Jamaica,* written in 1905, by Mr. Frank Cundall:

"The principal timbers of Jamaica are: for posts—cashaw, boarwood, pigeon-wood, candlewood, wild ebony (or bulls hoof), male pimento, juniper, cedar, fiddlewood, and bullet-wood; for railway- or tramway-sleepers—bullet-wood, fiddlewood, and boarwood; for carpentry—cedar, bullet-wood, and broad leaf; for cabinet work—mahogany, cedar, yacca, mahoe, and satin wood. Boarwood contains a juice that blisters and is proof against insect life for a long period. It is the best description of wood in the island for lasting between earth and air; it is also excellent for paving stables, streets, etc.; it is elastic and durable. In 1896, specimens of twenty-two timbers were sent to the Imperial Institute for testing, with the following result: The highest-grown timber of the series was mountain mahoe, weighing 33½ lb. per cubic foot, or a little less than ordinary pine used in this country (England). Considering its very low density, its strength is fairly good. Next in order of density is Blue Mountain yacca, which weighs 38½ lb. per cubic foot, and the strength of which is distinctly greater than that of mountain mahoe.

"The fault of tropical woods, from a constructional point of view, is their hardness and heaviness. Among the Jamaica timbers there is a group of very hard timbers. Yokewood, cherry-bullet, naseberry-bullet, rosewood, and lignum-vitæ weigh from 70½ to 75½ lb. per cubic foot; such wood can be used for very special purposes. They are all considerably heavier than water. Excepting for shearing the strength coefficients of the heaviest wood, lignum-vitæ, were not very high. Among woods of specially light weight, mountain yacca and St. Anne's yacca are good. Among woods of moderately heavy character, hog-gum, yellow sanders, satin-wood, and mammee-sapota have good strength coefficients. Among woods heavier than water, prune and the cherry, and naseberry-bullet seem the best."

Geology.—The geology of Jamaica consists, in a general way, of Cretaceous Limestone, overlain by Tertiary sediments. These are associated with igneous rocks ranging from granites and diorites of the plutonic series, to porphyries and tuffs of the volcanic series. Some, at least, of the igneous rocks have intruded the sediments, and the usual phenomena of contact metamorphism may be easily observed. These geological relationships, taken in conjunction with the indication of several kinds of ore in numerous localities, should make the country worthy of closer investigation with the view of possible development. The notes in the succeeding paragraphs are based on the old report of 1869.

Copper.—The ores of this metal are widely found in Jamaica, and assume different characters according to the geological circumstances and formations in which they occur. Generally it seems that the deposits instead of being concentrated into veins and masses are too much disseminated throughout the rock; and that, notwithstanding the richness of some of the localities, yet the great expense attending on mining in this country and the absence of skilled and intelligent labour render the practical utilization of such resources highly difficult and uncertain. [Note.—The writer did not realize either modern mining developments or modern transport facilities.] The occurrence of copper ore in the granites of the West Indies is very general; for instance, a fine deposit is known in the Virgin Islands.

In the Portland district numerous large blocks of grey copper have been found in the beds of small streams, evidently resulting from the destruction of some lode, for the porphyry decomposes easily, and is then washed away by the rains. The contents of the lodes, being siliceous, withstand this action, and are not easily removed by a current of water on account of their greater weight or specific gravity.

Copper occurs near Port Royal, in the metamorphosed sandstone and shales in the form of carbonate, but in no place in such quantities as to justify an opinion as to the extent of the vein or deposit. The occurrence of copper in the granitic series may be regarded as more permanent for mining.

In the St. Andrew's district copper ores are generally associated with the granitic series, disseminated in small particles or in larger masses of one or two inches in diameter; but in no part of this district has a definite lode of this mineral been observed on the surface. Although there are many favourable indications, as yet no mining explorations have been carried out on a scale sufficient to determine that the district is entitled to be regarded as a mineral country.

In the Metcalfe district, the mineral deposit of Job's Hill is situated near the junction of the red porphyry and conglomerate; the former supervenes so suddenly that one might at first suppose the copper ores were contained in the conglomerate. Such, however, is not the case, and they must be entirely referred to the igneous rock. Unfortunately, the gallery or excavation has been completely filled with debris, and therefore the actual scene of the explorations does not admit of any detailed examination. The copper minerals at Job's Hill are principally grey ores, and rich in metal. About 80 tons of this mineral were obtained, but the expectations of the company not being realized after spending £20,000 (exclusive of the purchase of the freehold), the enterprise was abandoned at the end of six or seven months. It is to be regretted that in place of importing an expensive staff, and incurring many unnecessary expenses, a portion of this large sum was not devoted to careful and complete exploration, so as to determine thoroughly the mineral character of the rock. If mining operations were resumed, inexpensive preliminary explorations should be first instituted, and prosecuted with great caution. At Sue River the occurrence of copper minerals presents several variations from the foregoing details. The enclosing rock is a species of syenite, but in contact at a short distance with a porphyry similar to that of Job's Hill. The ore is copper pyrites, disseminated through the mass of the rock, but in much larger grains than at Job's Hill, and when concentrated occupying definite joints of the rock, and sometimes bounded by a distinct wall. Cupriferous minerals occur over the whole of the adjacent region, as at Wey Hill, Dee Side, Rose Hill, etc., and correspond in most particulars with the two instances above detailed.

Near Mocha, on the Swift River, in the syenite there is a small vein of sulphide of copper; and for some distance around there are particles of this mineral scattered through the rock. Lower down the river, at Holdsworthy's, another vein of copper appears, which is rather richer than the last-mentioned. The Old Spanish mine near Leckie's exposes the black oxide and sulphide of copper in vein about 18 inches wide; the indications are good as far as can be seen.

In the St. Thomas district, at Mount Recovery, in the south-east part, there is a semblance of a mineral zone. A prominent boss covered with vegetation distinct from that of the adjacent surface and marked with green copper stains, is observed ranging 10–20 degrees north of west. On examination the mineralized rock is found to be several yards in breadth, composed of a highly siliceous matrix, with a small proportion of copper pyrites partially transformed into carbonate of copper. Many other cupriferous localities are known, as Coffe, Newport, Golden Grove, etc.

In the St. John district, on the western part of Juan de Bolas on a south-western slope near the head of Rock River, a copper mine has been opened, and some few hundred-weights were extracted containing a large amount of arsenical pyrites. This ore has been found also on several spots on the same side of the mountain ; but as all the rocks bear a marked sedimentary character the deductions are that the ore does not occur in veins, but as stratified deposits. This circumstance, however, should not deter exploration, as the same peculiarity characterizes the mines of Cobre in the island of Cuba. Detached pieces of good ore are found in the river courses, but no true mineral lode has yet been observed, and the deposits containing this mineral are confined exclusively above the Cretaceous rocks.

In Clarendon district the mines at Charing Cross and Stamford Hill afford a nearer approach to true lodes or mineral veins than any of the other metalliferous deposits of Jamaica. Though not contained in mechanical fissures, the deposits are bounded by definite walls and characterized by distinct gangue and ribs of ore. The width of the veins sometimes attains 16 in., and they seem to occupy definite zones or lines of weakness in the porphyry, the containing rock. Whether these zones are due to fracture or merely to a divisional structure of the rock is uncertain, but the latter supposition is more likely. Where the copper ores approach the surface the sulphides are converted by the action of surface water into blue or green carbonates, which contain gold disseminated in small grains and threads. Owing to the ignorance of the parties working the mine, the gold was regarded as pyrites, and as the carbonates of copper were considered of too low a percentage to bear the cost of export, they were thrown among the debris of the mine into a deep gully. When the Government geologists visited these mines in February and April, 1865, they found the lower adit the only one in a condition for inspection ; the upper shafts and levels had collapsed, and the weeds and bushes had grown over their entrances.

During the year 1858 some specimens of blue and green carbonates of copper from either Stamford Hill or Charing Cross mine were given to Mr. Lewis MacKinnon by the late Mr. Edward Thompson as specimens of copper ore from the Clarendon Mines ; as such they were regarded, and on Mr. MacKinnon's leaving Halse Hall, where he then resided, these specimens of copper ore were thrown away. While the geologist was surveying this district he occupied the house at Halse Hall, during which time the assistant geologist discovered a small piece of these specimens, and it was discovered that what had been considered by the miners as copper pyrites was gold ; subsequently another and larger piece was examined, and was found to contain sufficient gold to be considered a gold ore, the value of which was estimated at from £60 to £70 per ton, besides the copper, which would yield from 12 to 15%. By the statement published in De Cordova's prices current December 31, 1857, it will be seen that 207 tons 15 cwt. 3 qr. 15 lb. were raised and shipped by the Wheal Jamaica Company, in proving the Charing Cross mine to that date. Had these mines been worked by an individual instead of a company encumbered by a staff of officers, and had due attention been given to the value of the ores, it should have proved a profitable undertaking. The thickness of the deposit or vein was 16 in. on the north-western course, and on the south-eastern also.

From the Stamford Hill mines there have been some shipments, but there is no published account of the amount. Small quantities were also shipped from Gold and Friendship mines, the latter rich in arsenical pyrites. At Arthur's Seat a similar copper deposit has been discovered, but not worked.

In the Westmorland district, near the stone pillar marking the boundary line between Hanover and Westmorland, and not far from the old works of Jones Morland, there are indications of copper ore in the trap sandstone. At another place near Williams Morland indications of copper similar to the above appear. Nearly opposite the junction of Bailey's River with the Great River on the roadside in the purple and grey trap shale, there is some green carbonate of copper, which occurs in thin shales between the bedding and also disseminated throughout the beds.

Lead.—In the St. Andrew's district the ores of lead occur at the Hope Mines, accompanied by blende and copper minerals. The lead is in the form of sulphide (galena) and cupreous sulphate-carbonate (caledonite). Some specimens were submitted to the geologists as coming from Silver Hill on the north-east of the district, but the geologists saw only a bed of shale impregnated with crystals of iron pyrites at the place where the lead ore was said to have been extracted. There is also a report of a deposit at Hall's Delight in the same district, where some values both in lead and silver are supposed to have been obtained.

In Metcalfe district galena and iron pyrites and a little sulphide of copper occurs in a vein which crosses the Ugly River near Thomsfield. This vein was found about 1850, and was worked for a short time and then abandoned. The mouths of the two old drifts are still to be seen, one on the riverside which went in about fifty yards, and the other some 50 ft. higher up on the vein. The vein is seen in the bed of the river, and is about 4 or 5 in. wide; it contains iron pyrites enclosing sulphides of lead. The surrounding rock is a fine-grained compact sandstone, which is of a bluish-grey colour, massive and jointed. It belongs to the metamorphosed series.

Manganese.—In the Portland district, at Boston, there is a deposit of manganese ore associated with a large proportion of oxide of iron. Near this deposit are larger ones of the oxides of iron, which might be worked profitably if they were situated in Europe. On the west bank of the Dry River (Marshall's Hall) large blocks of manganese are seen embedded in the porphyry; large quantities are scattered over the surface and in the streams. As no excavation has been made, the mode of occurrence of this mineral cannot be ascertained; it exists, however, in considerable quantities, and might be worked at a profit if it was not situated at so great a distance from the coast. [In 1884 some of this ore was actually mined and carried down to sea-level on mule-back. Since then a good Government road has been built within 1½ miles of the place.]

Determination of this manganese ore gave the following results:—Pyrolusite, 88·9%; water, lime, iron, copper, arsenic, 4·41%; insoluble residue 6·7%.

In commerce this would be taken as a material of the second quality, the first quality containing from 93 to 97% of pyrolusite. [This analysis gives a content of 56·2%. An analysis made at McGill University, Montreal, from another sample gave a manganese content of 40% and an iron content of 1·5%.]

Iron.—With regard to iron ores it does not seem likely that the lateritic type of iron ore which has been found in Cuba will be found in Jamaica, but indications of iron ore of a contact type have been found. Analyses of this iron showed an iron content of 63% with some manganese in it.

CONCLUSION.—The logical conclusion of a careful consideration of the situation is that while the present industries carried on in the island of Jamaica are of an agricultural nature, and mining efforts have so far not met with success, the numerous indications of all sorts of minerals and the fact that the last geological work was done in the island before the value of economic geology was realized, would warrant the statement that mineral resources of this island of the West Indies had not been given a fair trial.

The World's Petroleum Output

The American Petroleum Institute estimates the output of petroleum throughout the world during 1921 as follows:—

	1920 Barrels	1921 Barrels
United States	443,402,000	469,639,000
Mexico	163,540,000	195,064,000
Russia	25,430,000	28,500,000
Dutch East Indies	17,529,000	18,000,000
Persia	12,353,000	14,600,000
Roumania	7,435,000	8,340,000
India	7,500,000	6,864,000
Poland (Galicia)	5,606,000	3,665,000
Peru	2,817,000	3,568,000
Japan and Formosa	2,140,000	2,600,000
Trinidad	2,083,000	2,354,000
Argentina	1,666,000	1,747,000
Egypt	1,042,000	1,181,000
Venezuela	457,000	1,078,000
France	389,000	392,000
Germany	212,000	200,000
Canada	197,000	190,000
Italy	34,000	35,000
Algeria	4,000	3,000
England	3,000	3,000
Others	1,016,000	1,000,000
Total	694,853,000	759,030,000

THE GEOCHEMICAL FUNCTIONS OF WATER

By J. MORROW CAMPBELL, D.Sc., M.Inst.M.M.

INTRODUCTION.—That part of the science of chemistry the object of which is to ascertain the origin and study the nature of the various substances composing the earth may conveniently be called geochemistry. It has not received the attention it deserves, especially in England, where there has been among geologists a marked tendency to follow traditional lines. Stratigraphy and palæontology occupy more than their fair share of attention to the exclusion of geochemistry and the economic side of geology. Had a reasonably keen interest been taken in the subject we should not be to-day without a laboratory properly equipped for studying the chemical and physical problems of geology.

Geochemistry deals only with natural substances and the conditions under which they developed; artificial compounds are outside its province. The preparation of natural substances by methods essentially different from natural ones is useful, for in this way information of value may be gained. The fact that a mineral may be synthesized under certain conditions does not justify the assumption that it developed naturally under similar conditions unless those conditions may be reasonably assumed to have existed in nature.

This paper is an attempt to assist in the solution of certain geological problems by the correlation of many experimental data and facts observed in nature bearing on some of the geochemical functions of water. Exhaustive treatment of the subject is not aimed at.

The number of laboratory experiments the results of which have been published is very great. Most of them deal with the synthesis of minerals. The methods adopted in many cases were not such as conform to the conditions of nature. It is seventy-two years since Daubrée published details of his method of synthesis of cassiterite. As a result "pneumatolysis" became, like "Mesopotamia," a "blessed word." Daubrée was followed by a host of imitators, who tried almost every conceivable substance, volatile and non-volatile, as flux or catalytic agent in their experiments.

Many of the results obtained in laboratory work, while interesting scientifically, are of no practical value in geology. As examples two of these may be cited. Silica is dissolved by molten silver and is deposited therefrom on cooling in crystalline form. Silica also dissolves in lithium tungstate from which on cooling it separates as quartz.

When we consider that the presence of water in rock magmas is admitted, it is somewhat surprising that its functions have received so little consideration and been so little studied in the laboratory.

SYNTHESIS OF TYPICAL ROCK-FORMING MINERALS

(*a*) *Ferro-Magnesian Minerals.*—All these minerals that are typical constituents of basic rocks are easily synthesized by the fusion together of their component oxides. The alkali amphiboles, which are common in acidic rocks, have never been synthesized. Hornblende, also a common constituent of acidic rocks, develops only under pressure and apparently requires the presence of a flux for its formation. Water favours its development at a lower temperature than any other flux. Orthorhombic amphibole heated with water under pressure to about 400° C. is altered to the monoclinic variety.

(*b*) *Basic Felspars.*—These may readily be obtained by the fusion together of their constituent oxides at ordinary pressures and without the aid of a flux. The nearer they approach the anorthite end of the series the more easily they are prepared.

(*c*) *Acid Felspars.*—All attempts to prepare these in crystalline form by simple dry fusion have failed. They develop, however, when their constituent oxides are heated together in the presence of water under pressure. Chrustchoff prepared orthoclase in this way at 300°. They have been prepared in a variety of other ways, but the presence of a flux is essential.

Albite will not crystallize on cooling from simple fusion, but will do so from fusion with magnetite. When silica, alumina, potash, and tungstic oxide are fused together at over 900° orthoclase is produced. These two facts are interesting scientifically, but they cannot be regarded as having any geological significance.

A molten magma resists change of state, and solids will develop from it only at the lowest possible temperature. The alkali felspars form in the presence of water in the vicinity of 300°, a lower temperature than that at which they form in the presence of any other flux. We are therefore justified in assuming that the development of alkali felspars in nature is conditioned by the presence of water. They probably form at much lower temperatures than experiment has yet demonstrated, for Daly cites a case in which both albite and orthoclase had formed in a marine mud below 100°.

(*d*) *The Micas.*—The principal rock-forming micas are muscovite and biotite. Both contain hydroxyl as an essential constituent. No really satisfactory synthesis of either is on record. Since they contain hydroxyl it is obvious that water must be used in any attempt to synthesize them. Several investigators have reported the formation of various micas by the fusion of anhydrous material, but, whatever the products may have been, they certainly were not either normal biotite or muscovite.

(*e*) *Crystalline Silica.*—The result of work done in the laboratory on the production of crystalline silica is very instructive and provides an excellent example of the enormous difference between the limiting temperatures of the formation of quartz and tridymite, when the experiments are conducted under purely artificial conditions, and when they conform as nearly as possible to those that we are justified in assuming exist in nature.

Silica alone cannot be converted into quartz by fusion. When heated with water in a closed tube at 200° to 300° a homogeneous liquid results, from which, on slow cooling, crystals of quartz develop. If heated to over 300° tridymite results. Amorphous silica heated to 750° with an alkaline tungstate yielded quartz on cooling, and if heated to over 900° tridymite formed. Brun used the vapour of an alkaline chloride with silica producing quartz at 700° to 750° and tridymite at 800° to 1,000°. Quensel states that silica heated with tungstic oxide yielded quartz below 1,000° and tridymite above. Alkaline tungstates, chlorides, and tungstic oxide certainly were not usually factors in the production of quartz in nature.

It appears that the transition temperature of quartz to tridymite in the presence of water under pressure is about 300°, whereas in the dry way it is 860° to 880°. As with the alkali felspars so with quartz the fact that it develops at a lower temperature in the presence of water than in any other way leads us to the conclusion that the presence of water is a condition of its development in nature.

Water and Silica

Silica is practically insoluble in water at any temperature under ordinary atmospheric pressure. When heated with much less than its own weight of water to 200° under pressure a homogeneous liquid results which, if cooled rapidly, sets as a jelly, and, if cooled slowly, deposits crystals of quartz. This homogeneous liquid is regarded by many as a simple solution of silica. I cannot so regard it. If it is, the phenomenon is unique. We know of no other substance insoluble in water at 100° and 760°mm. which becomes freely soluble on raising the temperature 100° and increasing the pressure.

Since in all the recorded experiments of this type pressure was produced by the expansive force of water vapour on heating in a closed vessel, we may reasonably suspect that, were pressure applied artificially with nitrogen or other inert gas previous to heat being applied, silica might be dissolved by water at a temperature of 100° or even lower.

The solubility of silica in water appears to be conditioned, within a certain undefined temperature range, entirely by pressure. On chemical grounds the only apparent explanation of this is that chemical combination takes place with the formation of silicic acid. On physical grounds we have no explanation, for simple solutions are not materially affected by pressure. The solubility of silica in water under pressure therefore provides strong presumptive evidence that under such conditions silicic acid exists and that it is fusible at quite moderate temperatures.

The silicic acids are chain compounds in which the silicon atoms are united to one another, not directly, but through the medium of oxygen atoms. No matter how long the chain may be each molecule contains only four hydroxyl groups ; therefore a small quantity of water is capable, under suitable conditions, of dissolving many times its own weight of silica and of maintaining it in the liquid state below 300°.

Silica appears to be incapable of combining with water at atmospheric pressure, but experimental data indicate that the simpler silicic acids can exist in an unstable form in aqueous solution at such pressure. The greater the pressure the greater appears to be the capacity of water to take silica into solution.

Barus heated glass with water and obtained a homogeneous liquid. Can we regard this as a simple aqueous solution? Daubrée, by heating water only in a sealed glass tube to below redness and cooling, obtained quartz crystals.

J. Koenigsberger and W. J. Müller heated glass and water in a closed steel tube to over 300° and cooled slowly. Opened while still hot, solids were found which consisted of tridymite, quartz, and felspar. The hot liquid portion was separated and on cooling deposited quartz and opaline silica. The glass all passed into solution, but not simple solution. It was completely decomposed, for no glass remained after cooling. Glass heated alone to 300° is not decomposed, but it is in the presence of water under pressure. Nothing else was present, therefore water decomposes glass at 300°. Glass is a double silicate in which silica is combined with two or more bases. The fact that combination took place proves the existence of chemical affinity between silica and the bases under the conditions ruling when the glass was formed. In the experiment there were no physical conditions adequate to dissociate silica from the bases, but dissociation took place, for silica was liberated. The only substance present that could have brought about this dissociation was water. Even if we assume for the moment that silica and water under the conditions were capable of forming a simple solution, this physical attraction would not be adequate to overcome the bond uniting silica to the bases. A stronger affinity must have existed between either the bases or the silica and water; otherwise the old union could not have been severed. The chemical affinity of water for the bases is quite inadequate to remove them from combination. The only solution of the problem appears to be that, under the physical conditions of the experiment, water has an affinity for silica stronger than that of the bases already combined with it. The probability, therefore, is that silicic acid is formed and that its dissociation at diminished pressure results in deposition of crystalline silica, the formation of felspar, and the later deposition of quartz and opal.

We find that the result of the action of water on a double silicate is the production of the same minerals that develop in nature under similar conditions. The formation of felspar is an important point, for it proves that an alkali felspar can develop in a silicic acid solution and be deposited therefrom before quartz and at a temperature below the critical point of water.

The experiment quoted is one of a number of a similar nature carried out by Chrustschoff, Baur, Friedel, Sarasin, and others. In every case the subject of research was the conditions of formation of quartz and tridymite. Many other investigators, including Daubrée and Bruhns, introduced fluorides, chlorides, etc., thus complicating the problem and imposing conditions unusual in nature. Had the object of research been the action of water on silicates, doubtless the information obtained would have been of much more value from the present point of view. The data available are admittedly scanty, but they furnish quite adequate grounds for argument, and, unless they are controverted by other laboratory data, we seem to be justified in accepting the hypothesis that provide the simplest explanation, namely, that silica enters into combination with water and that the silicic acids are capable of existing at pressures of a few hundred pounds per square inch.

Modifications of Quartz

Le Chatelier first drew attention to the existence of two modifications of quartz, now called α and β quartz. The limiting conditions of the formation of these have been determined by Wright and Larsen. They are distinguished by difference in the hydrofluoric acid etch figures. The former develops only below 575°, and, even if since its formation it has been heated over that temperature, its structure is altered in such a way that the etch figure reveals the fact. All vein quartz is said to be of the α modification, and therefore to have been formed below 575°.

Plutonic Rocks

For present purposes it is necessary for us to consider only those forms of primary siliceous rock that assumed the solid state at considerable depth. The study of volcanic rocks does not assist us because they gave off, while still liquid, volatile substances which were essential to their existence as lavas. We do not know with certainty either the nature or amount of these substances.

Plutonic rocks belong to two general types, basaltic and granitic. They are often associated with one another, but there is a sharp division between them; they never merge into one another.

It seems probable that the amount of basaltic rock in existence is many times greater than the amount of granitic rock, and that the quantity of free bases in the former is more than adequate to combine with all the free quartz in the latter.

The leading characteristics of basaltic rocks are: Their poorness in alkalies, especially potash; the presence of free bases; the absence of combined water in their essential minerals; by simple fusion of their component oxides all their essential minerals are formed.

The leading characteristics of granitic rocks are: Their richness in alkalies, especially potash; the presence of free silica; the presence of combined water; both quartz and orthoclase can be formed readily at moderate temperatures in the presence of water under pressure; the micas, containing hydroxyl, can develop only in the presence of water. Hornblende, another mineral common in granite, can be formed in the presence of water under pressure. None of these minerals can be formed by simple fusion.

The Functions of Water in Rock Magmas

Rock magmas are generally admitted to contain water. Most geologists appear to believe that water was an original constituent of even primeval magma and that it existed there for the greater part in simple solution.

The so-called water of biotite and muscovite is present as hydroxyl. This is a basic radicle the hydrogen of which replaces an equivalent of alkali metal, usually potash. Since the water of solid mica exists as hydroxyl it is evident that it was present in the same condition in mica in solution; therefore some of the water of a granitic magma is present in it as hydroxyl, and experiment points to it all being in that condition. Most of the water of primary magma passes into the acid differentiate, and, if present as hydroxyl in the latter, it was in the same state of combination in the former.

We must endeavour to ascertain the probability as to whether water was or was not a primary constituent of rock magmas. If the reactions taking place in Koenigsberger and Müller's experiment have been correctly interpreted, it is difficult to believe water to have been a primary constituent, for its presence would apparently result in the instant breaking up of certain silicates with the formation of free bases and silicic acid. It would be possible only if at very high temperatures the affinity of water for silica was low or non-existent. If this were so, a rearrangement of radicles would take place and solubilities would undergo a drastic change when temperature fell to a point at which the increased affinity of water for silica overcame the bond by which the latter was united to certain bases. Magmatic differentiation must be caused by some modification of chemical affinities within the magma due either to change of temperature (or pressure) or to the introduction of some new material factor—water—from without.

Some years ago it was the general belief that the water of magmas percolated down from the surface; then this theory was abandoned in favour of the idea that water is a primary constituent. The writer is inclined to favour the older theory, since it appears to simplify the problem as to why primary magma splits into two well-defined fractions; but neither theory of the origin of magmatic water is incompatible with the differentiation hypothesis now advanced.

Water takes part in many other reactions within magmas, with sulphides, oxides of iron, etc., but these are regarded as of secondary importance. They were considered at some length by Goodchild in his work on Magmatic Ores.

(*a*) *Magmatic Differentiation.*—It is hardly credible that when the siliceous crust of the earth first assumed the liquid state it was not of fairly uniform composition. Few geologists will not admit the probability that basaltic and granitic magmas were the result of differentiation of a primeval magma of intermediate composition. This split into acidic and basic fractions took place while the magma was still liquid. The weight of evidence leads us to believe that limited miscibility of the component minerals of the two fractions, resulting in liquation, was the mechanical cause of the split. No satisfactory chemical explanation of the cause has yet appeared.

Fractional crystallization has been largely used to explain differentiation, but no mere physical process can be regarded as adequate to explain the first great split. Crystallization is only part of the general cooling process, and it is not at all certain that the first split was directly connected with cooling. Recognition of the fact that compounds may be crystalline and yet liquid helps us to realize what may happen in crystallization differentiation ; it may not be swarms of crystals that sink but a shower of liquid non-consolute drops.

We have seen that the essential minerals of granitic magma almost certainly develop in the presence of water and that the essential minerals of basaltic magma are formed by simple dry fusion. The first split in primeval magma consists in the separation of a light aqueous fraction from a practically dry, denser melt. The greater part of the potash accompanies the aqueous portion because potash compounds are more soluble than the corresponding soda compounds and much more so than those of calcium and magnesium. It thus appears more than probable that the first differentiation of primeval magma is due entirely to the action of water.

If silica in the dry condition is added to basalt and the mixture fused, combination takes place and the free bases disappear. In the primeval magma it is inconceivable that we could have had free silica and free oxide of iron co-existing for any long period. What was it that tore away silica from combination in silicates? Crystallization was not competent to do it. The very fact of some silica having been liberated implies that it went away in union with a partner more attractive than the one left behind. It is unreasonable even to suggest that silica could give up its partner in a cooling magma and go away absolutely uncombined.

We may regard the granitic magma as an aqueous or silicic acid extract from a magma of intermediate composition, the amount of water available having been limited. This hypothesis furnishes a rational explanation of not only the origin of granitic rocks but also of all their characteristics, including their richness in potash which presently accepted theories admittedly fail to do.

(*b*) *The Solidification of Granite.*—A granitic magma is generally supposed to be a solution (neglecting accessory minerals) of mica, felspar, and silica in one another. The usual sequence of crystallization of the components is: mica first, followed by felspar, and lastly quartz. The theory of eutectics, which applies to simple solutions, has been invoked to explain why the most refractory mineral is the last to crystallize. Common salt forms a simple solution with water and the eutectic ratio is 23·6% NaCl to 76·4% water. This solution when cooled sufficiently will form a solid of the same composition. If water in the mixture exceeds the above ratio pure ice will separate out on cooling, and if salt is in excess NaCl, $2H_2O$ will separate, at a higher temperature in each case than that at which the eutectic mixture solidifies, and the quantity that separates in each case will be such as to leave the eutectic ratio in the liquid portion.

The eutectic ratio of a simple solution of orthoclase and silica is given by Vogt as 74·25% of the former to 25·75% of the latter. If the orthoclase-silica mixture of granite is a true solution we should have the excess of either component separating in the solid condition before the eutectic freezes. The ratio of quartz to orthoclase in many granites exceeds that in the eutectic, but we do not find it separating first; orthoclase almost always crystallizes first no matter which component is in excess. We have good reason therefore *prima facie* for not regarding the orthoclase-silica of granite as a eutectic. If we cool a fused mixture of orthoclase and silica we do not get either component separating out in the crystalline condition. A true eutectic mixture of the pure components cannot be induced to form crystals on cooling. If we introduce water under pressure crystallization will take place, but the mixture is no longer truly eutectic.

Observation leads us to assert positively that water is invariably present when a granitic magma is solidifying and that it is expelled as an aqueous mother-liquor as the solid rock forms. The component minerals therefore develop from an aqueous medium which cannot possibly act as an orthoclase-quartz eutectic any more than a mixture of salt and water could act normally if hydrochloric acid were present.

If the water of granitic magma were present merely in solution this argument would still be valid, but both experiment and observation point to it as being combined in silicic acids the composition of which varies with pressure, and this hypothesis explains in the simplest way why quartz is the last mineral to develop in granite.

(*c*) *Quartz and Pegmatite Veins.*—The composition of the mother-liquor expelled by granitic magma on consolidation appears to vary very greatly. It undoubtedly contains the whole excess of water not retained in the granite, and its composition will depend upon temperature and pressure, but probably more on the latter than the former.

Veins on the periphery of granite batholiths have been observed filled by a large number of thin alternate layers of mica and quartz.

This is much more likely to be caused by oscillations of pressure than of temperature. Many veins in similar positions are filled with pegmatite but most with quartz. There is no essential difference in the origin of the two, for we may frequently see pegmatite merging into almost pure quartz. While few such quartz veins are quite free of mica it is the exception to find felspars in them. Mica is frequently the first mineral to be deposited on the walls of fissures, often forming a continuous thin layer, the remaining space being filled with quartz.

Outside the granite, between its periphery and the overlying sedimentary rocks, great sheets of pegmatite have been observed as much as 200 ft. in thickness. Often this pegmatite is of normal composition, and at other times it becomes more and more siliceous, until it is practically pure quartz, consisting in some cases of an aggregation of vast numbers of bunches of quartz crystals developed radially from nuclei only a few inches apart. These appear in many superposed layers indicating a repeated alternation of conditions.

It is difficult to explain these phenomena otherwise than on the assumptions that silicic acids exist in the mother-liquor, that their solvent power varies with pressure, and that they dissociate depositing quartz on reduction of pressure.

(*d*) *Greisenization*.—We find that a granitic mass in which the only mica is biotite is frequently accompanied by pegmatite containing muscovite and no biotite. There is evidence that this muscovite results from the alteration of potash felspar, while still in solution, by the acid mother-liquor. Many veins on the granite periphery are filled with a mixture of muscovite and quartz to which no name but pegmatite is applicable. This change of orthoclase to muscovite is characteristic of the action of mother-liquor near and outside the periphery of the granite.

In the walls of fissures in the granite up which mother-liquor has passed we find felspar converted into mica, usually muscovite. The altered rock is called greisen. The process by which the change is effected is the same whether the felspar so altered is in solution or crystallized in the granite. The liquid that produces the change is highly siliceous, yet it takes up more silica from the felspar and parts with some of its water which combines as hydroxyl in the muscovite. Was this water present in the mother-liquor as free water or combined as hydroxyl? If present as water it entered into combination as hydroxyl with silica at the moment of formation of the mica. This may be conceivable when the change takes place in solution, but it is hard to believe when solid felspar is altered to mica by a passing solution. If we admit the water to be combined as hydroxyl the greisenization process is easy to understand.

The walls of fissures in granite have not always undergone greisenization, and when it does occur its extent may vary enormously. The granite may be affected to only a fraction of an inch in depth or the change may penetrate many feet.

The mother-liquor that works the change, having very recently been given off by granite, would not normally be capable of attacking felspar, so we must regard greisenization as the result of abnormal conditions. These may be accounted for as follows: The greater the pressure the greater appears to be the capacity of water to combine with silica. As pressure increases, mono- and di-silicic acid take up more silica, forming the tri- and tetra-silicic acids, and to satisfy this tendency the liquor not only extracts silica from felspar but also parts with a portion of its water to the mica, thus, by both taking up silica and diminishing the amount of hydroxyl, it tends to establish equilibrium. Greisenization thus appears to be a result of increase of pressure, and its extent seems to depend upon the amount of such increase and the length of time it lasted.

Upon fissuring bringing about reduction of pressure, quartz deposits owing to the breaking down of the longer-chain silicic acid molecules.

On account of greisen often containing fluorine compounds such as topaz, the origin of which is attributed to pneumatolytic action, the formation of such minerals has been regarded as an essential part of the process of greisenization. The validity of this argument is rendered doubtful by the frequency with which greisen occurs in which such minerals do not exist.

The Origin of Free Silica

There appears to be little doubt that the amount of bases in the crust of the earth is adequate to combine with all the silica in existence. It is unlikely when the silicate crust of the earth assumed the liquid form that this primeval magma contained any free silica. It is established by experiment that an alkaline double silicate formed by dry fusion may break up when heated with water under pressure with the formation of felspar and free quartz. This evidence, combined with that of field work, leads us to the belief that the action of water in a primary magma is to split it into a basic and an acid portion. The former contains much free base capable normally of combining with silica, and the latter contains much free silica. Such a split is regarded as impossible in the absence of water.

The further action of water on basalt under magmatic conditions is to extract more silica, leaving a residue of ultra-basic rock. Serpentine has been observed traversed by veins of quartz-hornblende pegmatite and also of chalcedonic silica. It appears certain that these veins were the result of the action of water on the ultra-basic rock that yielded the serpentine.

The ultimate result of the action of water at magmatic temperatures on basic rocks seems to be the complete breakdown of silicates and the entire removal of silica, leaving a residue of metallic ores such as chromite, ilmenite, magnetite, and corundum.

The action of water in breaking down silicates and generating free silica is not confined to magmas, however, for a similar process goes on at intermediate temperatures, that is, below the critical point of water.

Many silicates containing magnesia give up part of their silica and combine with water forming serpentine. This change proceeds without liquefaction of the rock. Great masses of peridotite, gabbro, etc., have undergone this change. It takes place at considerable depth and affects thousands of feet in thickness of rock in some cases. The further action of water assisted by other reagents may be to extract the bases from serpentine, leaving a residue of quartz and opaline silica, that is, the generation of free silica.

The function of water in metamorphism is an important one, but the chemistry of metamorphism is not well understood. Experimental work on the action of water at, say, 200° to 300° on silicates is badly needed. We do not know what the effect would be, but we have good reason for believing that in many cases silica would be liberated. At and near the surface the destruction of silicates proceeds rapidly. Water is essential in this process, but it is assisted by oxygen, carbon dioxide, alkaline carbonates, and other reagents. The hydrous silicates of alumina are the most stable under these conditions, but even these are broken up in the laterization process, silica being removed and free alumina remaining behind. It appears, therefore, that the action of water at any temperature on silicates is to decompose them with the separation in the free state of either a part or the whole of the silica.

The formation in nature of all quartz is determined by aqueous action. We may go even so far as to say that almost the whole of the free silica in existence has been liberated from combination with bases by the action of water. It is difficult to believe that, unless there is a strong affinity between silica and water and actual chemical union between them at moderate temperatures and pressures, this wholesale decomposition of silicates could have taken place by means of water.

Water and Cassiterite

The synthesis of cassiterite by Daubrée initiated the use of the halogen compounds in the artificial preparation of so-called high-temperature minerals, and upon it was founded the belief in the pneumatolytic origin of cassiterite.

It is not credible that the halogen compounds or fluxes such as tungstic oxide could have had any part in the natural development of such minerals as have been produced artificially by their use unless the temperature at which they develop is lower than that at which they are produced by means of water. Water is always present where these minerals develop ; we cannot disregard the Le Chatelier principle.

As long ago as 1880 J. H. Collins entered a strong protest against the pneumatolytic origin of cassiterite and supported it with important evidence from Cornish deposits indicating its aqueous origin.

Cassiterite is a product of the oxidation of metallic tin and comes into existence thus at a much lower temperature than Daubrée used. Cassiterite occurs in several parts of the world in deposits in which neither tourmaline nor topaz, fluorite nor appatite accompanies it. It occurs enclosed within quartz crystals deposited simultaneously with quartz, also encrusting quartz crystals and therefore of later development. It occurs with quartz and other minerals filling cracks under various conditions, and notably in wolfram ore. In stalactitic form and as wood-tin it is admittedly deposited from aqueous solution. In these forms it appears in some cases to be secondary, and said to be derived from stannite; but wood-tin is found in deposits in which no stannite is known to occur. These forms of tin oxide are assumed, probably correctly, to have been deposited at a lower temperature than ordinary cassiterite.

From the results of experimental work on the production of crystalline silica we have seen that quartz can be formed under pressure from amorphous silica in the presence of water at a much lower temperature than it can be in any other way. We are therefore justified in assuming that most, if not all, of the quartz in nature has been produced in the presence of water, or that quartz is of aqueous origin. We have also seen that, with water present, quartz develops from 300° down to 200°, and that above 300° tridymite forms. It is not uncommon to find cassiterite deposited in practically pure quartz and simultaneously with it. During this process water was present. Tridymite is known to occur only very rarely in association with cassiterite. It must therefore be assumed that cassiterite, when occurring in quartz, developed along with the quartz and consequently at a temperature usually below 300°.

Daubrée in his original synthesis of cassiterite used stannic chloride with aqueous vapour at a red heat. Stannic fluoride also yields it under similar conditions. Stannic fluoride also yields it under similar conditions. Stannic chloride boils at 114° and the fluoride at 705°. The extreme rarity of chlorine-bearing minerals in tin deposits precluded the assumption that tin was transported in combination with chlorine. Minerals containing fluorine are common and consequently the theory that tin is introduced into its deposits as the gaseous fluoride has gained general acceptance. This process would demand a temperature approaching if not exceeding 800° because the boiling point of stannic fluoride would probably be raised considerably at magmatic pressures. The existence of such a temperature is incompatible with the production simultaneously of quartz in any form. Vein quartz moreover indicates by etch figure that it has not been subjected to a temperature over 575°.

Since cassiterite in the form of stalactites and wood-tin is of aqueous origin water is capable under certain conditions of carrying stannic oxide in solution and at a lower temperature than that at which primary cassiterite is usually formed. There appears to be no objection to our believing that secondary cassiterite may be deposited from water; why then should it be denied that water at a higher temperature can carry stannic oxide and deposit it as ordinary cassiterite? And why so much insistence on pneumatolytic origin?

Silica and stannic oxide are similar in that at 760 mm. they are both so sparingly soluble in water that we may regard them as insoluble. Nature proves cassiterite in some forms to have been deposited from aqueous solution, but at what temperature we do not know; probably below 100°, but certainly not much above it. Wood-tin is sometimes associated with opaline silica which is indicative of a temperature of deposition below 180°. Ordinary cassiterite is usually associated with quartz which appears to be of aqueous origin and to have been deposited between 180° and 300°. In some Cornish tin ores quartz is absent. Theoretical considerations, such as the occasional replacement of silica by stannic oxide in silicates, combined with the evidence of certain Cornish and Burmese tin ores, have led the writer to reject the opinion, previously expressed, that stannic oxide was transported in silicic acid solution. That theory does not accord with all the facts and must be discarded in favour of one that does.

The appearance of cavities in veins lined by cassiterite crystals so closely resembles that of cavities lined by quartz crystals as to suggest similarity of origin. Wood-tin bears quite a strong resemblance to chalcedony. In chemical behaviour silica and stannic oxide resemble one another in many respects. They are both acid anhydrides combining with alkalies to form salts soluble in water. Stannic hydroxide, $Sn(OH)_4$, or orthostannic acid, exists as an unstable solid under ordinary conditions. Orthosilicic acid possibly may be able to exist in dilute aqueous solution under ordinary conditions, but is not known in the dry state. Like orthostannic acid it is appreciably soluble in acids before drying and insoluble after.

Experiment indicates that the silicic acids are capable of existing at elevated pressures and have a low melting point. By analogy we may reason that stannic acid, which exists under ordinary conditions, should act similarly. It should be much more stable at elevated pressures and have a melting point much lower than that of the anhydrous oxide.

Evidence as to the probability of silicic acid breaking up on reduction of pressure and depositing anhydrous silica has already been recited. If stannic acid exists under magmatic conditions it is probable that it breaks up on reduction of pressure into water and anhydrous oxide, the latter developing as ordinary cassiterite or as wood-tin depending upon the temperature at the time of release of pressure. On this hypothesis we can explain all the phenomena of the occurrence of tin oxide in nature. The laboratory work necessary for testing this hypothesis would be comparatively simple, and the writer is endeavouring to get it carried out.

Orthoclase crystals are known to have been replaced by a mixture of muscovite, quartz, and cassiterite. If a solution of stannic acid reacted with orthoclase this is exactly the result we should obtain :—

Orthoclase = $K_2O.Al_2O_3.6SiO_2$, trebled = $3K_2O.3Al_2O_3.18SiO_2$.

Muscovite = $K_2O.2H_2O.3Al_2O_3.6SiO_2$.

Potash has been partly replaced by water, alumina remains constant, and two-thirds of the silica is set free. The water, if taken from stannic acid, $Sn(OH)_4$, would cause the precipitation of one molecule of cassiterite for each molecule of muscovite created. Simultaneously we should have twelve molecules of silica and two of potash liberated. If the potash combined with its equivalent of silica and passed away a large quantity of the latter would remain free and be deposited as quartz. Theoretically according to this reaction we should find the mixture to consist of about three parts by weight of cassiterite to four of muscovite and a variable amount of quartz.

It is not argued that these reactions would proceed quantitatively as a single series unaffected by other reactions probably proceeding simultaneously, but the hypothesis advanced at least explains the change on a reasonable theoretical basis which cannot be done on the assumption that tin was introduced in the gaseous condition.

Cassiterite is deposited through a very much wider range of temperature and pressure than wolframite, and the phenomena of the occurrence together of the two minerals seems to the writer to be quite irreconcilable with the pneumatolytic or any other theory that postulates their being carried in magmatic liquids in a similar state of combination.

Water is an essential factor in the transport of all other primary ores that are not injected in a state of fusion but its ability to carry them in simple solution is very doubtful.

It is hoped that geologists with tin experience may express their opinions of the value of the stannic acid hypothesis in explaining natural phenomena.

EFFECT OF DYKES ON PITCH OF ORE-BODIES

By LESLIE B. WILLIAMS, B.A., B.E., M.Inst.M.M.

Variation in the distribution of the economically valuable content of ore-bodies is axiomatic. Apart from the inevitable differences caused by the manner in which the ore-bodies are formed and which, in the case of so-called lodes, has to do with the impregnation of masses of materials which are not homogeneous, there is also, in general, a localization of the valuable content into what are known as " shoots or ore " and the localization, as a rule, is referred to some particular point or line in the plane of the ore body.

Generally speaking an ore-body is considered to be sufficiently described when its length, width, strike, and dip are given. The meaning of these attributes is well understood. Each of them, however, refers to a horizontal plane through some point in the ore-body.

In the case of tabular deposits with definite dips, that is to say, bodies which are not horizontal and whose dimensions (length and breadth) are determined by reference to a horizontal plane, there is another feature of great importance. This is the position which the limits of the ore-body (or shoots of ore) occupy at different depths below the horizontal plane referred to.

At the surface the body may be considered to be bounded by four planes, two representing the hanging wall and foot-wall, and the other two vertical planes at right angles to the strike of the body and representing the limits of length.

When work has proceeded below the surface it is often found that the last two planes no longer represent the boundaries (in length) of the ore-body, but that the body appears to have moved relatively to them.

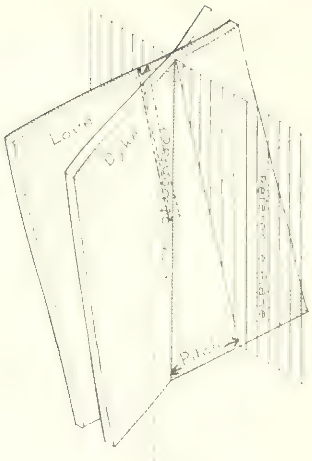


FIG 1.

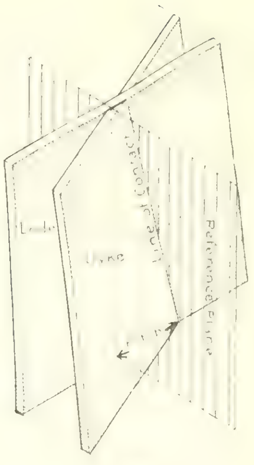


FIG 2

The limiting vertical planes no longer coincide with the original surface planes, but appear to have moved to one side or the other of the originals at definite depths below the surface. In such cases the ore-body is said to pitch and the amount of pitch is measured in the horizontal plane of the ore-body by the distance (along the strike) between corresponding vertical planes at each point of observation.

In the case of lenticular bodies, the pitch of the major axis is generally the most important, and in describing such bodies it is essential that when pitch is mentioned the particular feature to which the term refers should be given. A lenticular body or shoot, for instance, may have a definite pitch so far as its axis is concerned, while its limits on either side may pitch towards or away from this axis, or the original reference planes.

The causes of pitch may be inherent in the ore-bodies themselves, and once the pitch is determined may be of no great interest. In many cases, however, pitch may be due to extraneous causes, such as faults or dykes, the occurrence of which may have been subsequent to the formation of the ore-body ; or, as is so often the case, to the presence of rock masses whose nature has been such that the portions of them included in the fracturing and fissuring preparatory to the deposition of ore have been unfavourable for this deposition.

In one particular case which will be considered the pitch of the ore shoots was found to be due to the fact that the lode shear passed through a series of granite dykes which had previously penetrated the favourable rock (greenstone) and no deposition of ore occurred where these dykes were included in the shear.

It is essential that the causes should be studied wherever pitch occurs, as they may have a profound influence on the future of the mine. Pitch will usually be determined when two or more levels are opened in a mine. Whatever suitable feature of the ore shoot is chosen as a basis for determination, its deviation, between one level and the next below, from the vertical reference plane on the upper level will be the measure of the pitch of that particular feature. The amount of deviation will be the amount of pitch for the actual distance between the levels, and will be referred to in general terms as being so many feet to one side or the other of the original plane of reference, in a definite vertical depth or a corresponding depth on the underlie, if any.

The line of pitch may be shown by mapping on a plane parallel to that of the ore-body. In the case of lodes which are not vertical, it may also be shown by projection on the horizontal and longitudinal vertical sections of two separate levels, but the pitch itself is always measured in the plane of the ore-body and along its strike. Reference to the " angle of pitch " and its measurement has caused at times much confusion of ideas, since this angle differs according to the plane in which it is measured. It is preferable to refer to pitch in terms of distance for definite vertical or underlie depths.

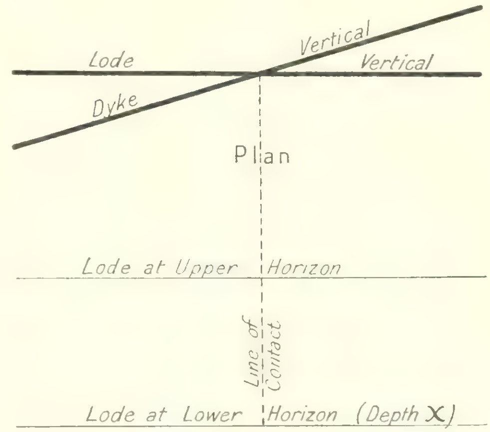
In cases where the pitch of an ore-body is simply the line of contact of an intruding dyke and the lode, or of some other prominent occurrence such as a well-marked fault, it may be a simple matter to determine and the direction of progress of mining work may be clearly defined. But there are cases in which the features may be very obscure, and instances are not wanting where failure to appreciate the effects arising out of these has led to the cessation of operations in ore-bodies of considerable promise.

Figs. 1 and 2 show in isometric projection a lode passing through a dyke. This is an instance taken from an actual occurrence. The portion of the dyke included in the lode (which is of later formation) is barren. In the particular case there is a series of these dykes and the portions included in the lode shear form a series of " blanks " in the ore channel. The pitch of the shoots of ore therefore will be dependent on the pitch of the line of contact between lode and dykes. In Fig. 1 the pitch is to the left of the reference plane, while in Fig. 2 it is to the right. It is obvious that the variation in pitch will depend on the relation between dip of lode and dip of dyke, and that the angle of convergence of each must also enter into the computation.

General cases may be established, and for the purpose of analysis the following case may be stated. A lode, in greenstone, whose strike is due north and south, includes in its channel a series of blanks, which are found to consist of crushed granite derived from dykes, which have penetrated the greenstone prior to the formation of the lode. These dykes, outside the ore channel, are found to be striking at an angle N. 15° W. How would the dip of the dykes affect the pitch of each blank, and therefore the pitch of the ore shoots ?

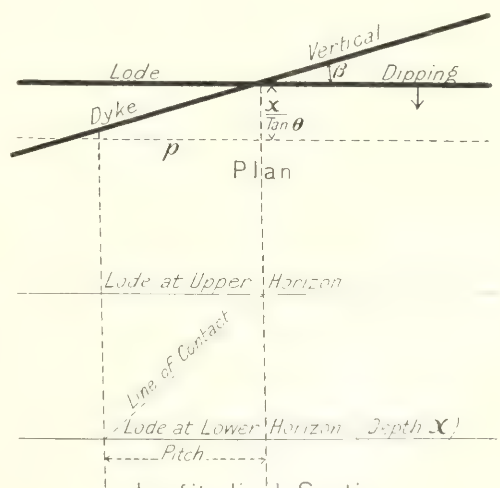
If the lode and dyke were vertical it will be seen at once that the line of contact of lode and dyke will be vertical also (Fig. 3). If, however, the dyke be vertical and the lode dip as shown in Fig. 4, it is obvious that the line of contact will pitch to the north at any arbitrary distance below. It will also be seen that as the dip of the lode decreases the amount of pitch will decrease until, when the lode is horizontal, there is a simple cutting out of the lode on the dyke itself.

If, on the other hand, the dyke dip as shown in Fig. 5 and the lode is vertical, the pitch will be to the north, and as the dip of the dyke decreases the pitch will increase until there is, when the dyke is horizontal, a simple cutting out of the lode on the dyke in depth. If the dyke dip in the opposite direction the direction of pitch is reversed. In every case it will be noted that the pitch is measured along the line of the lode. It will also be noted that the direction of dip has a definite effect on the direction of the pitch.



Longitudinal Section

Fig. 3.



Longitudinal Section

Fig. 4.

If, now, the lode and dyke have definite dips, it will be evident that a new factor has to be reckoned with, and this brings us to a consideration of the general case. Figs. 6, 7, 8, and 9 show the lode dipping in the one direction and a general variation of the pitch from north to south according to the direction and amount of dip of the dyke. For the purpose of analysis it will be necessary to assume the dip of lode and angle of convergence of lode and dyke to be constant. It is immaterial how these are taken, as the general case will cover every individual case. Let us assume that the lode is dipping west

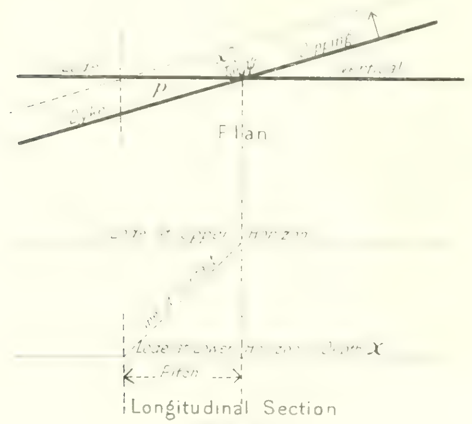


Fig. 5

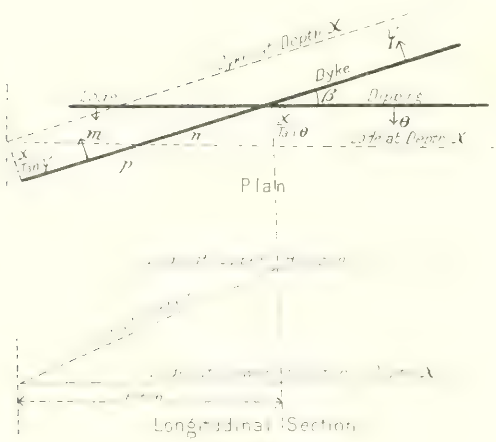


Fig. 6.

at an angle θ, and that the angle of convergence of lode and dyke is β, and that both are constant. It has been seen that in such a case if the dyke be vertical the pitch will be to the north. Since dips are measured from the horizontal plane a variation of the dip of the dyke from the vertical will cause it to be measured in two directions, namely, N. 75° E. and S. 75° W. The case could be considered by changing the dip from 0° to 180°, but it will be less confusing to take them in the manner first mentioned.

The first general case may be considered from Fig. 6. Here the dip of lode is against that of the dyke. Let ψ be the dip of the dyke in a direction N. 75° E. From the diagram $p = m + n$. The vertical depth is taken as x.

$$\text{Then } \frac{x}{m \tan\psi} = \sin\beta.$$

$$\therefore m = \frac{x}{\tan\psi \sin\beta} \quad (1)$$

$$\text{Also } \frac{x}{n \tan\theta} = \tan\beta.$$

$$\therefore n = \frac{x}{\tan\theta \tan\beta} \quad (2)$$

$$\text{Thus, } m+n = x\left\{\frac{1}{\tan\psi \sin\beta} + \frac{1}{\tan\theta \tan\beta}\right\} \quad (3)$$

Now x may be taken as unity, in which case p is the measure of the pitch for unit vertical depth, and is proportional to

$$\frac{1}{\sin\beta}\left\{\frac{1}{\tan\psi} + \frac{\cos\beta}{\tan\theta}\right\} \quad (4)$$

If $\psi = 90°$, $\frac{1}{\tan\psi}$ vanishes, and the pitch (see in equation 3) is proportional to $\frac{1}{\tan\theta \tan\beta}$, and equals $\frac{x}{\tan\theta \tan\beta}$.

In Fig. 4 there is the particular case where $\frac{x}{p \tan\theta} = \tan\beta$, so that $p = \frac{x}{\tan\theta \tan\beta}$, as before.

As the angle of dip increases beyond 90° $\tan\psi$ changes sign and the expression (4) above becomes $\frac{1}{\sin\beta}\left\{\frac{\cos\beta}{\tan\theta} + \text{A negative value}\right\}$ (5).

It is better, however, to consider the angle of dip as less than 90° and positive, but it will be obvious that the expression (5) vanishes for values of ψ greater than 90°, when $\frac{\cos\beta}{\tan\theta} = \frac{1}{\tan\psi}$.

This is the condition for *no pitch*, that is when $\frac{\tan \text{Angle of Dip of Lode}}{\tan \text{Angle of Dip of Dyke}} = \text{Cos Angle}$ of Convergence.

Taking ψ, the dip of the dyke, from the horizontal in a direction S. 75° W., and referring to Fig. 7, we have the pitch, $p = \frac{b}{\tan\beta}$.

$$\text{Now } a + b = \frac{x}{\tan\theta}.$$

And since $\frac{x}{a \tan \psi} = \cos \beta$,

$$a = \frac{x}{\tan \psi \cos \beta}$$

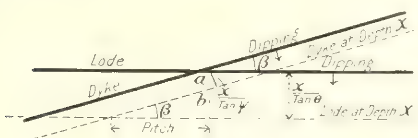
$$\therefore b = \frac{x}{\tan \theta} - \frac{x}{\tan \psi \cos \beta}$$

$$\text{and } p = x \left(\frac{1}{\tan \theta \tan \beta} - \frac{1}{\tan \psi \sin \beta} \right)$$

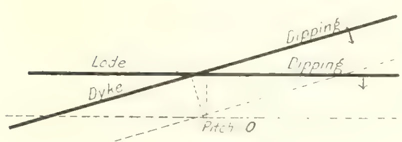
$$= \frac{x}{\sin \beta} \left(\frac{\cos \beta}{\tan \theta} - \frac{1}{\tan \psi} \right) \qquad (6)$$

As before, when $\frac{\cos \beta}{\tan \theta} = \frac{1}{\tan \psi}$, this expression vanishes, and the condition for *no pitch* is that

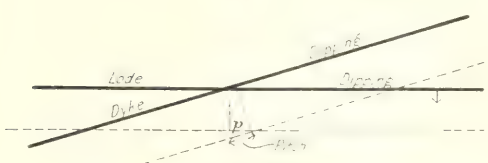
$$\frac{\text{tan Angle of Dip of Lode}}{\text{tan Angle of Dip of Dyke}} = \text{cos Angle of Convergence.}$$



Plan
Fig. 7.



Plan
Fig. 8.



Plan
Fig. 9

Referring now to Fig 9, it will be seen that for certain conditions the pitch changes from a positive value to 0 and beyond that point, that is to say, from north to south. This can be deduced from expression (6).

If $\frac{1}{\tan \psi}$ is less than $\frac{\cos \beta}{\tan \theta}$, the pitch will be to the north.

If $\frac{1}{\tan \psi}$ is equal to $\frac{\cos \beta}{\tan \theta}$, there will be no pitch.

If $\frac{1}{\tan \psi}$ is greater than $\frac{\cos \beta}{\tan \theta}$, the pitch will be to the south.

The cases quoted have been observed in actual occurrences in Western Australia. In these there has been practically no movement. But it is possible for development work to fail because of the small angle of convergence and more particularly when the angles of dip of lode and dyke are nearly the same.

It will be observed from Fig. 1 how winzing in an ore-body may pass out of the productive rock, and with a series of dykes at frequent intervals this has been known to lead to the abandonment of a productive ore-body.

Fig. 6 really shows two conditions. Looked at from the south end, it shows the dips of lode and dyke diverging. After passing the point of contact they converge and the pitch is maintained.

The cases where, instead of the intersection of dykes with lodes, there have been actual movements of the lode on fault planes are rather more complicated, but may be analysed on the same lines. The investigation of overthrust faults affecting tabular bodies offers some interesting features which are not generally referred to in the textbooks. It is not proposed to deal with them here. The variations are numerous.

The reference above to overthrust faults is intended to include all those movements which in Western Australia are generally classed as "reverse faults." A true definition of this latter term is required.

Helium for Airships.—The burning of an American airship, which followed so soon on the similar disaster at Hull, has served to draw attention once more to the use of helium instead of hydrogen as a buoying agent. In December last we gave particulars of the world's resources of helium and of its application in the manner indicated. The United States Navy already has an airship filled with helium, and it recently gave a public demonstration by flying from Norfolk, Virginia, to Washington and back. There is already talk of a passenger airship using helium to ply between New York and San Francisco, but this is no doubt rather a hope than a probability at present. It is estimated that four hundred million cubic feet of helium is at present going to waste every year in the natural gas centres. As the cost of separation has been immensely reduced lately, standing now at about 15 cents per cu. ft., a campaign of conservation and extraction may be expected.

BOOK REVIEWS

Treatise on Petroleum. By Sir BOVERTON REDWOOD. Three volumes ; cloth, octavo, with many illustrations and maps. Fourth edition ; revised and largely rewritten by the author, in association with many specialists. Price £5 5s. net. London : Charles Griffin & Co., Ltd.

Sir Boverton Redwood's life extended from prior to the inauguration of the oil industry, as we know it, and in the development of this industry he took an active and leading part. He was afforded, therefore, peculiarly favourable opportunities for the accumulation and digestion of the mass of material contained in the present edition of his *Treatise on Petroleum*. He died in harness leaving this edition in an incomplete form, and its preparation for publication has been made possible by the loyal co-operation of a numerous band of helpers to whom credit is given in the preface. Under these conditions it is obvious that the edition scarcely realizes the ideal at which he aimed, and the present reviewers feel that attention might be drawn to the search for possible directions in which approximation towards such ideal may be arrived at, and it is well to say that any criticisms in this review are not given in any carping spirit.

It would not be possible in a breath to express the potent influence which this treatise has had on petroleum and its allied sciences and industries since the first publication in 1896. The work is of world-wide fame. It has become a classic in the literature of petroleum, where, owing to the existence of many special treatises, supremacy can only be maintained by dexterous correlation of facts and masterly reasoning. It was the first comprehensive work of its kind in the English or any other language. It has now expanded into three volumes containing 1,383 pages, divided into eleven sections, with appendices on statistics, import duties and Thames Conservancy, a bibliography, addendum, and index.

The first volume comprises four sections, dealing with the " Historical Account of the Petroleum Industry," " The Geological and Geographical Distribution of Petroleum and Natural Gas," " The Physical and Chemical Properties of Petroleum and Natural Gas," and " The Origin of Petroleum and Natural Gas ". The second volume likewise embraces four sections, those of " The Production of Petroleum, Natural Gas, and Ozokerite," " Refining of Petroleum," " The Shale-Oil and Allied Industries," and " The Transport Storage and Distribution of Petroleum." The third volume deals with " The Testing of Crude Petroleum, Petroleum, and Shale-Oil Products, Ozokerite, and Asphalt," " The Uses of Petroleum and its Products," regulations, and the appendices already mentioned.

Thus the original scheme has been adhered to and the get-up of the book remains as it was. The most noticeable change is with regard to maps, which have been vastly improved and augmented. These include the map of the United States on a scale of 1 : 2,500,000 showing the oil and gas fields as published by the United States Geological Survey, and is here reproduced in four sections. While welcoming these maps it must be confessed that they do make the book unhandy, and we would prefer to have found them either in folders at the end of each volume or possibly in a special case. In bringing out new editions of such a monumental treatise as this, it is a difficult matter to decide what to discard ; we hope, however, that before the next edition appears the same service that has been done in the present edition with regard to the maps will be extended to the other plates, many of which are by no means up-to-date. Thus, for example, the survival of Plate 6, giving geological " Cross Sections in the Baku District," and Plate 21, showing " Russian Drilling Tools," however valuable from the historical point of view, could only be justified if supplemented by more recent developments in Russian geology and drilling respectively.

The first two sections are both arranged geographically under the headings of countries. This leads to some overlapping and causes confusion in reference to any particular district, a difficulty which is rendered none the less owing to the intercalation of the bulky maps. In future revisions these two sections might with advantage be combined, the historical data forming simply an introduction to the geological data of each country, or possibly a general historical account alone forming an introductory chapter.

The historical notes are excellent, but some of the newer material is rather undigested. The statement on p. 9 that " the Russian freefall system may be regarded as the Canadian system modified to suit local conditions " is scarcely correct, for the freefall long preceded the Canadian.

The addition of a map of the Apsheron Peninsula would much facilitate reference to the numerous localities mentioned near Baku, and the transliteration of certain of these might well be improved. Such places as " Bog Bala " and " Mud Mountains " are not recognizable.

The grouping of Galicia and Roumania under the term " Carpathian Fields " is praiseworthy, although some confusion is subsequently introduced by separating the Roumanian fields both in the text (pp. 25, 189) and in Plates 2 and 3. In times when political boundaries are in a state of flux, anything that establishes physical units should be welcomed. This has already been attempted by A. Beeby Thompson, and deserves development, as by so doing fields of minor importance may often be grouped in their proper significance relative to each other.

The part devoted to the United States has been well revised, and although David White's paper on the " Unmined Supply of Petroleum in the United States " may be regarded rather as prophesy than history, we are glad it has been included in the work though a more convenient place for it would be under " Duration of Oil and Gas Supplies " on p. 172. Throughout this paper the United States gallon is used without comment.

Other countries the treatment of which calls for special commendation are Mexico, the West Indies, and South America.

The historical section is not an easy one to write, particularly so as to preserve the proper balance between the recent events and those more remote, since the former often loom so much out of proportion. The author has succeeded well in doing this, and the 160 pages covered by the section may justly be quoted as an exceedingly compact and useful section. There is no need to decry the historical side ; it might well be expanded, for the sources from which the older material is derived are usually quite inaccessible nowadays to the average student, yet they are of continual service in estimating the causes of past failures.

The geological and geographical section only occupies 95 pages, and must be regarded as too short. It opens with some 15 pages of general discussion covering oil and gas reservoir rocks, the structural conditions affecting the accumulation of oil and gas, the older ideas as to oil lines and oil in fissures and pockets, the association of salt with petroleum, pressure in wells and its causes, the association of mud-volcanoes, duration of supplies, affinity of clay for petroleum, and the occurrence of ozokerite and asphalt rock. This does not do justice to the voluminous literature dealing with the occurrence of oil that has been produced in recent years, practically nothing being devoted to the detailed petrology of oil-sands or the associated sediments, or to the consideration of migration or other relative movements between the hydrocarbons and water. The brevity of this portion is unrelieved by a single illustration, a remark which applies generally to the section as a whole, for besides the maps there are only Figs. 8 and 9, showing respectively a section to scale 1 : 125,000 through Schodnica–Boryslaw in Galicia, and a columnar section of the Woodsfield Quadrangle, Ohio, together with Plate 6 giving the sections of Barbot de Marni and Sjögren at Baku. This absence of illustrations is a serious disadvantage, particularly to students, and moreover the limited space given to this section does not permit of adequate treatment in detail.

Somewhat more ambitious than the rest is the part dealing with the United States, covering some 24 pages and written under the auspices of the Director of the United States Geological Survey. This, except that references might well be given for readers who require more detail, and that it suffers from the general absence of illustrations, is an exceedingly concise and clear exposition of the general geology of the various oil-fields of the United States treated under the headings of the individual States.

Needless to say, to deal adequately with oilfield geology would require an entire volume and the joint efforts of experts on the various fields. It is the most pressing need for the next edition.

Section 3, which deals with the physical and chemical properties of petroleum and natural gas, has been carefully and judiciously revised. The wonderfully complete compilation of the physical and chemical data of petroleum of the last edition has been rendered still more valuable by being brought up to date with additional details and tables of physical properties and constants. Short descriptions of a refractometer and polarimeter would be advantageous for completion of the physical portion. A new departure has been made with respect to the arrangement of the hydrocarbons which are known to occur in petroleum. Greater clearness is thereby gained, and we hope that in the next edition the chemical composition of petroleum and natural gas will be expanded and allotted to a distinctive separate section. It is interesting to note that a chemical problem, namely, synthetic acids from petroleum, has been outlined; a further extension on these lines is desirable, for such possibilities open up new fields of research and of the resources of petroleum. The significance of the part dealing with methods for examination of petroleum for chemical constituents cannot be over-estimated. Pages 1,099 to 1,120, vol. iii, give the full statistical data relating to natural gas and natural-gas gasoline, and show the colossal production of these two commercial products and the unprecedented growth of the natural-gas gasoline industry since Fasenmeyer first applied himself to the manufacture of natural-gas condensates. Excellent chemical, physico-chemical, and technical descriptions are given for their production, which, unfortunately, are scattered in different sections in the three volumes. A sketch of a gasoline plant inserted in the text would have added to the lucidity of the subject matter. An important method for the technical analysis of natural gas is given too briefly and relegated to a reference, although the method is worthy of greater mention. Indeed, a descriptive account of the analytical examination of natural gas would be a valuable addition.

In the next section a succinct account is given of the much discussed and fascinating problem of the origin of bitumen. As regards this matter little further experimental work has been forthcoming during the past decade, and on that account the section has not received considerable extension. The author does not dogmatize. He remains almost entirely non-committal. He puts the various hypotheses which have from time to time been formulated, clearly and precisely, and leaves the reader to weigh the numerous considerations in their favour and form his own judgment. The necessity for further research in this field under conditions comparable with those in nature is emphasized, and the section concludes with the recognized position of the views expressed by Höfer and Engler as to petroleum being of a marine animal-vegetable origin, while natural gas is a secondary product of the same decomposition. "Probably, on the whole, the Engler-Höfer dual theory had at one time the largest number of adherents, but it has distinctly lost ground among geologists within recent years."

Section V treats of the important subject of production, here taken to include the whole field exploitation from the leasing of land, drilling of wells, and production as ordinarily understood, namely, pumping and other methods of extraction. This section has been carefully revised, and much of the historical side has been retained. It is questionable whether an exclusively geographical classification is the best way of treating this section, for there has been so much interdevelopment in the oil industry that most operations are considered much more simply on their own merits and in the order of their employment in the field. Thus the question of water shut-off might well stand independently of California, and the various forms of production, that is, pumping, bailing, air-lift, and swabbing should be treated together.

Consideration of the necessarily condensed information as regards drilling which must ensue from the small compass of this section, might well have lead to the exclusion of such systems as the Davis-Calyx and the Fauvelle, which have merely historical association with oil-well drilling, and the space thus freed could have been devoted to more recent practical data. In connexion with the description of the freefall system, as used in Russia, by some mistake jars are introduced in place of the freefall (a modified Fabian type is the one actually in use there), while, on the other hand, we note a freefall figured on Plate 22, as used with the Canadian tools. Furthermore, the use of the wireline as an adjunct to pole-drilling in the Boryslaw-Tustanowice field is no longer current practice.

The subject-matter of Section VI is very important, dealing as it does with the various stages in the refining of petroleum. This section is not exceptional to the general tendency to treat each subject from the historical standpoint, and, however advantageous this may be, due importance should be given to recent advances, which in consequence have suffered lack of prominence. Increased interest would have been attained by including an absorption method of refining (technical), and a brief outline of the work on the elimination of sulphur from sulphur compounds by the use of catalysts (theoretical). The possibilities of the conversion of petroleum and petroleum residues into anthracene and aromatic hydrocarbons could have been dealt with more logically in the section on chemical composition in Volume I. The limitation of the theoretical consideration of the process of cracking may cause disappointment to many readers. The influence of temperature, the effect of pressure, and the use of catalysts on the cracking of petroleum oils are dealt with only superficially. A fuller account of catalysts (theoretical and practical bearing) and of catalytic processes, upon which a vast amount of experimental work has been expended within recent years, although they have not come into great use, is desirable. Moreover, sufficient detail is not given of methods of hydrogenation.

The account of the shale-oil industry has been revised along broad lines, and considerable fresh material has been introduced. The industry developed by British enterprise claims a large amount of interest; its latent and decided economic possibilities are of national importance. Certain of the principal factors of shale-oil technology have been indicated in such a manner that they should serve as a valuable basis for further investigations into, and development of, the resources of shale.

Unfortunately, the impression gained on reading is that the chemical and physical aspects of the subject have not been sufficiently incorporated, and also recent methods (both in this and in the succeeding section of testing) for the evaluation of oil-shale and for the examination of crude shale-oil are absent. Considerations of the best utilization of space force us to feel that in this section, as well as in the others, the disadvantages outweigh the advantages in giving verbatim reports of papers instead of a well-considered abstract.

The section dealing with the transport, storage, and distribution of petroleum is good, but labours under undue attention to the statistical and historical at the expense of the engineering side. It requires much more room for the adequate treatment of this side, and certain matter which now occupies space, such as the list of vessels carrying petroleum in bulk, the experiments relating to explosive mixtures and statistical matter generally, might well be relegated to the appendices. We should have liked to see Mr. Barringer allowed a freer hand.

Scientifically and technically Section IX is of vital importance, for it deals with the testing of crude petroleum, petroleum and shale-oil products, ozokerite, and asphalt. Comparison of the subject matter with that of the corresponding section of the previous edition shows practically little change. In connexion with the methods and apparatus for the determination of the flash point of oils, no effort has been made to present a clear exposition of the subject, but much care has been taken to make the list of testers described as exhaustive as possible. The part played by Sir Frederick Abel and the author in fixing the flash-point is of deep historical interest.

Under distillation we find many methods mentioned, yet the method of Engler as modified by Ubbelohde and adopted by the international commission is omitted; moreover, the paragraphs dealing with dephlegmators and still heads could with advantage be extended with further descriptions of recent types of the distilling columns which are in use.

For many years attention has been directed to the advantage of expressing viscosity in absolute units, and we find prominence is given to the very interesting portion dealing with the inter-relationships of Redwood and Engler seconds with absolute viscosity; also methods are given for conversion of the viscosity values obtained by various instruments to absolute measure. A short discussion of the methods available for calculating the viscosity of hydrocarbon oil mixtures would be a useful extension.

Certain important physical tests need amplifying to render them of practical value. Certain important chemical tests are omitted altogether, and we would state that from a chemical standpoint the majority of the tests given are obsolete and quite unworthy of a standard book of reference. The section as a whole requires drastic revision, careful selection of its facts, the marshalling of the latter in a lucid and logical order, with a complete bibliography in the form of reference footnotes, so that full advantage would be gained by certain excellent data which in its present setting are submerged. To write a comprehensive section dealing with both physical and chemical methods of analysis would be a most important contribution to the petroleum industry, and it would have been a source of justifiable pride to the author, whose efforts have contributed so much to modern methods of testing petroleum.

The extraordinary development in the industrial uses of petroleum and its products and the comprehensiveness of their applications is outlined in Section X. Recent advances in the different branches have assumed such vast proportions that these branches possess voluminous literature of their own which lie outside the confines of this work. The section commences with a general review of the use of petroleum products in various scientific and industrial fields, switch and transformer oils, and the principles underlying the various forms of lamps in which mineral oils are consumed, together with the author's collaborations with Sir Frederick Abel and their important suggestions on the subject of accidents with mineral-oil lamps. The short account of switch and transformer oils is a valuable contribution to this section.

Air gas, the carburetting of coal gas with vaporized hydrocarbons, air-gas machines, and carburettors are discussed together with the technology of oil gas and carburetted water gas, while the excellent survey of "petroleum as fuel" furnishes the reader with the specifications of the British Admiralty and United States Navy for fuel oil. The section, written with discriminating care, concludes with a consideration of petroleum engines, the principles and advantages of which, owing to limitation in the size of the work, could be illustrated only by the selection of a few out of the great number in use.

The third volume concludes with an appendix giving full statistical data relating to the United States, Galicia, Germany, etc., with regard to the production of crude oil, natural gas, natural gas gasoline, etc., and also a revised bibliography which, as stated in the preface, is not a complete bibliography of bitumenology. It would be preferable in an encyclopedic work of this kind to publish these parts in a separate volume and to insert in their place an extensive glossary of bitumenology which would be particularly serviceable.

The publishers and all concerned may be complimented upon their work. We trust, however, that it will be recognized that this present edition is merely to fill a pressing demand and that immediate steps will be taken to prepare a larger and more comprehensive edition which may truly be regarded as a fitting memorial to Sir Boverton Redwood and his work. The preparation of such a new edition can be done only by the united efforts of leading men in all branches, and will take time; and we venture to suggest that it should be done in collaboration with the Institution of Petroleum Technologists, that other memorial to Sir Boverton's activities. We have already indicated various directions in which extensions might run. That it would result in a much bulkier treatise is obvious, but we feel that should such lead to the introduction of individual volumes for the various sections this would be a great improvement. The separate volumes might then be sold separately, a great boon to the average student. The bibliography should be brought up to date, and all references in the text could conveniently be made direct to it. The maps and more important plates should form an atlas, and illustrations in the text should be multiplied. Finally, sections dealing with the commercial side, the relationship of the petroleum and by-product coal industries, and with conservation of the available resources, should be added.

T. G. MADGWICK.
C. E. WOOD.

Preliminary Report on Petroleum in Alaska. By GEORGE C. MARTIN. Bulletin 719, United States Geological Survey.

One unconsciously associates the word "Katalla" with any mention of petroleum in Alaska, and the opening up of this field in 1901, with its subsequent boom, will still be fresh in the minds of many readers. It is therefore interesting to find that during the twenty years that have elapsed since the first well was drilled at Katalla, progress, though slow, has centred largely round this field, notwithstanding the discovery of other prospects as a result of strenuous work under difficult geographical and geological circumstances.

The present bulletin describes briefly the trend of investigations to date, and the oil possibilities of certain areas within this territory. Petroleum indications are known from five districts in Alaska, four on the Pacific, and one on the Arctic coasts; the former comprise the Katalla, Yakataga, Iniskin Bay, and Cold Bay fields, the latter being the Smith Bay prospect. At the present time Katalla is the only field producing oil, and altogether some 56,000 barrels have been obtained for local requirements. The oil is of a paraffin base, varying in colour, gravity, and in petrol, kerosene, and lubricant contents; sulphur is typically absent. The recoverable petrol and distillate amount to about 63%.

Production is obtained from Tertiary rocks, but the stratigraphy and tectonics are as yet imperfectly worked out. There is ample evidence of much tangential and vertical displacement of the beds, but owing to the nature of the country, mapping of structures is fraught with the greatest difficulty, so that the geological evidence available must be regarded as being entirely local.

The text is prefaced by a few explanatory remarks by Mr. A. H. Brooks, who, while believing in the further development of oilfields in Alaska, does not predict startling discoveries. As he rightly observes companies engaged in oil-finding in this country need considerably more capital behind them than for similar propositions in the United States; exacting local conditions of climate, communications, and accessibility demand cautious procedure on the part of both investigator and investor, a warning not only applicable here, but also in other cases of oil-land development in remote parts of the world.

This report, with its generous provision of maps, illustrations, and sections, is well worth careful reading. H. B. MILNER.

Geology and Petroleum Resources of North-Western Kern County, California. By WALTER A. ENGLISH. Bulletin 721, United States Geological Survey.

This bulletin concerns the areal geology of a tract of country mainly located in the San Joaquin Valley, north-west of Kern County, California, and has been written with a view to making known the chances of finding oil in as yet untested properties within this tract; it, therefore, does not discuss at length the geological conditions obtaining in fields already developed, but the new information given constitutes an important contribution to our knowledge of this interesting country.

The Devil's Den, Lost Hills, North Belridge, Belridge, and Temblor Ranch oilfields are situated within this region, but the author adduces much evidence to show that development of new fields may reasonably be expected in the Temblor Valley (east of the Temblor Range), and in the San Joaquin Valley, the latter on the whole offering the better prospects. As is well known, production from this part of California is chiefly obtained from anticlinal structures, involving the Tertiary formations, especially the McKittrick beds overlying the Maricopa diatomaceous shales, both of Miocene age. The prospective area in the Temblor Valley embraces eastward-trending anticlines in the Maricopa series, with a possible yield of petroleum from a similar horizon to that occurring in the Temblor Ranch property. Forecasting conditions in the San Joaquin Valley is more difficult, largely owing to the thickness of alluvium present which masks practically all the solid geology. Under these circumstances development must be largely a matter of "wild-catting," though with the redeeming features of knowing the trend of regional structures and making allowances for synclinal areas of width approximating to that obtaining in parallel cases where outcrops have permitted more precise survey.

An excellent geological and topographical map of the country is provided, together with horizontal and vertical sections. The report is a notable addition to the technical publications of the United States Geological Survey, and one on which that department and the author may alike be congratulated.

H. B. MILNER.

The Microscopic Determination of the Non-Opaque Minerals. By ESPER S. LARSEN. Paper covers, octavo, 294 pages, illustrated. Bulletin 679 of the United States Geological Survey.

The use of the microscope as a means of determining minerals is constantly being extended, the ideal to aim at being a method comparable in accuracy but superior in speed to the chemical methods for the determination of acid and basic radicles in qualitative analysis. The examination of thin sections has been amplified by the use of microchemical tests, examination of crushed material in transmitted and reflected light, and the determination of the optical characters of small mineral fragments

The method advocated by the author depends on the last of these, consisting in the determination of the optical constants of minerals by their immersion in liquids of known refractive index.

For the method to be successful it was necessary to have more accurate determinations of the optical characters of some minerals than were previously available. This need has been met to a great extent by the author having accurately determined the optical constants of some five hundred mineral species.

The optical constants made use of are

the refractive indices α, β, and γ, the crystallographic orientation of the directions of vibration corresponding to these indices and the amount of absorption of light travelling in each of these directions.

The liquids used for immersion give a range of refractive indices from 1·333 to 1·741, and cheap and easily obtained liquids have been selected as far as possible. Solid media carry the scale up to 3·17, and concise directions as to the preparation and preservation of the media are given.

The author claims that half an hour is sufficient time for the determination of any mineral species by an experienced worker, and he claims that the method is applicable in the identification of crystalline products in chemistry, for artificial products have definite optical characters. It is also suggested as a method of use in metallurgy and ceramics.

After an introductory chapter the methods used are described in detail, followed by a short chapter on statistics of optical characters of minerals. Then comes a list of new data obtained by the author, occupying some 130 pages. The rest of the book is occupied by a table of minerals arranged according to their intermediate refractive indices, followed by a table of dara for the determination of the non-opaque minerals.

One cannot but admire the thoroughness with which the author has dealt with his subject. The chapter describing the methods employed is clearly written, though it errs on the side of brevity; but should be easily followed by the advanced student and experienced microscopist, who are referred to text-books on methods of optical measurement by the microscope.

The method advocated by the author is attractive in so far as the number of observations to be made is small, but considerable practice would be required to acquire the necessary skill for rapid and accurate determinations. It would, however, be a valuable method in the examination of artificial products, and in cases where the determination of the intimate purity of a mineral was required.

The book will be valued for the excellent determinative table by all who use the petrological microscope. It gives all the important optical characters of minerals, and includes many species which do not usually occur in works on microscopic mineralogy.

E. H. DAVISON.

LETTER TO THE EDITOR

Indian Iron Ores

The Editor:

SIR—I have read the paper on Indian iron ores by Mr. Ernest Parsons in your January number with a great deal of interest, particularly the theory advanced by him regarding the origin of these ores. Mr. Parsons would appear to accept the replacement theory chiefly because he finds it impossible to conceive of their having been formed by alteration and enrichment through surface waters, after the manner of the Lake Superior deposits. In this last he is quite right. The Indian iron ores are due only to a very small extent to surface enrichment. Anyone familiar with the Lake Superior ores would at once recognize the difference in type between the two. His replacement theory, however, would seem to present equal difficulties, some of which Mr. Parsons evidently appreciates.

In my paper on the "Ancient Sedimentary Iron Ores of British India" (*Economic Geology*, vol. x, No. 5, pp. 450–2), I called attention to the striking analogy between the Indian and the Brazilian ore deposits, and ventured to advance the theory that the Indian deposits had their origin in primary sedimentation; which theory had already been ably presented for the Brazilian deposits by C. K. Leith and E. C. Harder (*Economic Geology*, vol. vi, No. 7, pp. 683–6). I have since that time had occasion to examine some of the Brazilian deposits, with two results. I checked and confirmed to my own satisfaction Messrs. Leith and Harder's theory regarding their origin; and I further confirmed the analogy between them and the iron ores of India.

It is true, as pointed out in my paper above referred to, that a theory involving the deposition of such immense thicknesses of sediments or precipitates extremely rich in iron presents some difficulties. These do not appear to be insuperable, however. For example, Mr. E. C. Harder has published a notable paper on "Iron-Depositing Bacteria and their Geologic Relations" (U.S. Geological Survey, Professional Paper No. 113), in which he concludes (on page 52) that in the case of the Brazilian ores: "The iron was probably deposited as ferric hydrate by chemical and biological agencies at the same time as the associated clastic material." With reference to the Indian ores, he says: "The ores are supposed to be original sediments that were precipitated chemically as ferric hydroxide and later metamorphosed to their present form." With regard to this last it is perhaps only fair to note that he refers to my paper on the Indian ores and probably assumes no direct responsibility. At least, he sees nothing in my descriptions which violates his conception.

If we once accept the deposition of thick beds of richly iron-bearing material as conceivably possible, whether it be by direct magmatic contributions (as originally advanced for the Lake Superior ranges), or by indirect subsequent contributions through surface waters, in conjunction with chemical or biological agencies, the further application of the theory of primary sedimentation to all the deposits in British India of this type with which I am familiar is both natural and simple. None of the mental gymnastics involved in a replacement theory are called for.

C. M. WELD.

New York, *February* 27.

NEWS LETTERS

SOUTH AFRICA

March 11.

REVOLUTION SUPPLANTS THE STRIKE.—The situation in the Transvaal has changed from one particularly suited for discussion in a technical journal to one involving national issues of world-wide interest. On March 4 the augmented executive of the South African Industrial Federation recommended to their affiliated unions that a new ballot on the question of returning to work be taken. The militant or rebel forces of the unions thereupon took control, refused the ballot, and two days later called a general strike. In other words, on March 6 the mining strike was over and the Red Revolution began.

For over a week authority on the Rand has been in the hands of a wild and ruthless mob, encouraged in their attacks on the mines and the community by the strength of their commando organizations (formed under the eyes of a "patient" police force), by the unpreparedness of the Government's Popular Defence Force, by the active support or silent approval of Nationalist Republicans, and encouraged, above all, by the measure of early success in a campaign of destruction.

The Trades Unions and the Chamber of Mines are now almost out of the picture since March 4. We see the people divided into new factions. (1) The Government, with all moderate elements of the community in its support. (2) The so-called strikers or the revolutionaries, weirdly combining the Communist and Boer Republican extremists, aiming to destroy the Government and utilize the failure of the strike to fire all unthinking hot-heads into a war of wild and vindictive destruction. The other factions are little more than neutrals, with "sympathies." These are: (3) The more level-headed Nationalists, with their usual seats on the fence. (4) Moderate Labour, who were never enthusiastic even for a straightforward mining strike and have been intimidated into silence and inactivity, a big party, which will again come into its own, some day, under the leadership of the veteran Trades Unionist, A. Crawford. (5) Another faction, with sympathies already dangerously pronounced, is the army of natives and coloured people on the Rand.

EVENTS OBSCURE THE ISSUES.—Readers outside South Africa have commented that the present Rand strike is of extraordinarily wide interest, but has been very difficult to follow. The local problems of the *status quo* agreement, of the colour bar, of the contract system, and of the relative functions of white and black are obscure enough without introducing the political machinations of Boer Republican and British Communist (if we can credit a communist with a nationality). The exciting events of the day fill our minds here and give the oversea cablegrams their substance. So even at this juncture, with the future beyond prediction, a commentary on the chain of events in diary form may prove more instructive than a current history, to which the world's Press is doing good justice.

EARLY STAGES.—The prologue of the drama has covered seven years, during which the place of the skilled miner has been gradually taken, owing to wastage and to war vacancies, by the young Africander, drawn by good wages from his farm or dorp. At the end of the war over 65% of the men were of this country stock. By organization and threats, when they and the mining companies were equally enjoying their rewards as High-Price Profiteers, they were able to establish such strength as to make the Chamber of Mines believe that any concession was better than a refusal of their demands. The climax was reached when the mines agreed to collect fees on behalf of the unions. However, this folly has been long repented.

The power gained by the unions was so firm that the rank and file of young Africanders became genuinely imbued with an idea of their infallible strength and indispensability. By a generation of abnormal experience they had been taught that to ask 100 was to receive 50, to threaten was to win all. They realized their industrial power and, in time, were taught their political power, too; allying themselves with the advanced members of the Nationalist party, from whom they hoped to receive the greatest support in times of trouble. They retained the old English-speaking leaders, to a large extent, men most experienced in aggressive functions and organizations, who have not failed to take advantage of a keen, aggressive following.

All went well when the mining companies were prosperous in the enjoyment of the gold premium. But when the fall came—in gold and coal values—and when the urgent necessity for reduction of working costs arose, the men were wholly unprepared for the inevitable sacrifices to be made, sacrifices of the special concessions granted during the war and of other advantages enjoyed before the war, when the Rand was a richer field. Economic laws, understood by more enlightened groups of labourers, meant nothing to this population, blinded by their past successes and prosperity.

DIARY OF THE STRUGGLE.—Their attempted education by the Chamber of Mines commenced in earnest towards the end of 1921. What would happen when the gold premium fell was made clear, but when the price actually began to drop there seemed little progress beyond correspondence and discussions. So, finally, the Chamber of Mines laid down what was considered essential to keep the mines, as a whole, from disastrous decline, and, giving due notice of over a month, announced what changes there must be. Considering the critical situation, these changes were moderate enough, involving the gradual displacement of about 10% of the least skilled white employees and the modification of the contract system under which extravagant cheques were made (not earned) in stoping and development.

These changes, due on February 1, 1922, were under the Federation's consideration when the colliery companies found themselves forced to cut their munificent wages from 30s. to 25s. This precipitated the fight.

January 2. Coal miners strike. S.A.I. Federation decide to take a ballot (open, not secret) on the Chamber of Mines' gold mining decisions.

January 9. S.A.I.F. ballot result, 11,000 to 1,000 in favour of strike. Half the members did not vote and figures untrustworthy. Conference with Chamber of Mines. Operation of Chamber's notice of changes postponed to February 9.

January 10. All workers on mines, in town and engineering workshops, and at V.F. Power Co., go on strike, except men on certain "essential services."

January 11. Unions throughout S.A. are warned to be in readiness for general strike.

January 13. Men on "essential services" withdrawn.

January 14. Conference is commenced between Chamber of Mines and S.A.I.F. at Law Courts.

January 16. Strikers organize "processions" (embryonic commandoes).

January 19. "Commando" action by strikers in the Far East Rand.

January 26. Conference breaks up. Chairman, Judge Curlewis, advances ineffective proposal.

January 27. Strikers form their commandoes on organized lines. Complete deadlock.

February 3. Deputation of S.A.I.F. to General Smuts.

February 5. More marked signs of violence and intimidation, hitherto slight.

February 6. Alliance between strikers and the Nationalist Party completed at meeting in Raadzaal, Pretoria, when it was resolved "to support the workers to attain their rights."

February 12. General Smuts issues appeal to men to return to work, promising protection to those doing so, a promise he was later unable to adequately fulfil.

February 13. A few men respond to appeal.

February 15. Underground Officials' Association announce decision to attempt to work the mines. Strikers' commandoes invade Johannesburg streets.

February 17. Union Parliament at Capetown is opened and further futile discussions of no importance commenced.

February 19. The female detachments of commandoes become conspicuous in punishing men at work or their families.

February 21. Hooliganism and intimidation spread widely. Small dynamiting incidents commence.

February 24. Enrolment of special constables.

February 28. Commando encounter police at Boksburg gaol. Three strikers killed.

March 3. Important meeting of executive of S.A.I.F. Proposed deputation to Chamber of Mines.

March 4. S.A.I.F. recommends a fresh ballot be taken by the unions. Chamber of Mines refuses to recognize the S.A.I.F., and outlines its attitude in a strong letter, inclined to be abusive, but clear and effective.

March 6. Militant committee, formed from S.A.I.F. and unions, throw out ballot proposal and declare a general strike.

March 7. Attempted putting into effect of general strike. Failure to pull out railwaymen and postal employees. Wild hooliganism in Johannesburg and districts, especially in Far East Rand.

March 8. Attacks on natives by commandoes. Certain defence force units mobilized.

March 9. Red flag hoisted on Johannesburg Town Hall.

March 10. Martial law eventually proclaimed. Revolutionary attack in force on Brakpan Mine, East Rand, resulting in its capture and in numerous casualties.

March 11. Situation grave and Government forces unable to make any effective progress against Red forces, which were most strongly established in Fordsburg (western Johannesburg suburb) and the Brakpan-Benoni area (Far East Rand). General Smuts reaches Johannesburg.

March 12. Situation improved owing to appearance of Government commandoes in East and West Rand.

March 13–14. Military operations against the Reds develop with success. As the Prime Minister has said, there can be only one ending, from the military and political point of view. But the industrial issues—the effect on mining policy, the ability of the mines to speedily recover, to reduce their working expenses, and build up efficient labour forces after the upheaval—these are conditions yet beyond close prediction. Having regard to the large and efficient framework of officials and foremen, who have remained loyally upon the mines, and the ready replaceability of a big proportion of the strikers, there is every reason to take an optimistic view of future conditions in the gold mines, when the men have eventually learned their lesson.

TORONTO

March 9.

PORCUPINE.—A very active season is in prospect, present conditions being all favourable to a great expansion of the gold-mining industry. The leading companies are increasing their capacity, and many new enterprises are being undertaken. There has recently been a marked advance in mining securities, based on the promising outlook of the mining industry owing to improved operating conditions and the increasing purchasing power of gold. The only adverse circumstance, the lack of adequate electric power, will be overcome by the development at Sturgeon Falls on the Mattagami River of about 7,000 h.p., operations on which have already been commenced by the Northern Canada Power Co.

The annual financial statement of the Hollinger Consolidated showed a total income of $10,314,515, as compared with $7,162,611 for the previous year, operating profits being $5,091,659, as compared with $3,840,482. After deductions for taxes and depreciation and the payment of $3,198,000 in dividends, a balance of $828,927 was carried to surplus account, making a total surplus of $7,893,366. The total tonnage of ore milled was 1,072,493, of an average value of $9·67 per ton, and the ore reserves were valued at $42,716,027. At the annual meeting on March 8, President Noah A. Timmins, stated that the mine and mill were working at full capacity, handling over 4,000 tons of ore daily, and plans had been made for mining to a depth of 3,000 ft.

At the McIntyre, a new unit of the mill is being installed to treat the high-grade carbonaceous ore found in one part of the mine, which, when in operation, will increase the capacity of the mill from 550 to 800 tons daily. The shareholders of the McIntyre have authorized a change in the par value of the stock from $1 to $5.

The Dome Mines is opening up a new level at a depth of over $\frac{1}{4}$ mile, where extensive diamond drilling has indicated the occurrence of high-grade ore. Sufficient ore has been blocked out to keep the mill running at capacity for three or four years. Extensive alterations and additions are being made to the mill, which will largely increase the output. The shareholders have approved by-laws authorizing the repayment of capital and the reduction in the par value of the stock from $10 to $9.

The shaft of the Paymaster is being put down to a depth of 500 ft., where a cross-cut will be run to tap a wide ore-body. The Porcupine Vipond-North Thompson mine will be reopened in April, funds having been secured by the sale of 475,000 treasury shares at 15 cents. The shaft will be put down from 600 to 900 ft.

KIRKLAND LAKE.—A general reduction of wages by about 10% went into effect on March 1. Between 600 and 700 men were affected. General Manager W. R. Thomas, of the Tough Oakes, stated at the annual meeting that it was expected that the mill would be running early in April, and that No. 2 vein from which rich ore had been extracted, and which had faulted, had been picked up on the Burnside property. The shaft on the Sylvanite is down 300 ft., at which point lateral operations are being carried on. The proposal to effect a merger of the Hunton Kirkland with two groups of claims known as the Gibson-Duncan and the Slaght-Solomon was defeated when submitted to the shareholders of the Hunton. The annual report of the Wright-Hargreaves for 1921 shows a profit of $201,186 for the last eight months of the year, during which 36,081 tons of ore, nearly all from development work, yielded $468,665. The average value of the ore treated was $13. Broken ore on hand December 31 amounted to 25,085 tons. Arrangements have been made for a merger of the Ontario Kirkland and the Montreal-Kirkland involving the formation of a new company capitalized at $5,000,000, of which $1,500,000 will be allotted to the Ontario-Kirkland and £1,725,000 to the Montreal-Kirkland. Machinery sufficiently powerful to carry on operations at a depth of several hundred feet is being taken to the King Kirkland, where numerous good veins have been opened on the surface and gold content proved to a depth of 100 ft. The Hyland-Kirkland has changed hands and British capital has become largely interested. Surface exploration and diamond drilling will be undertaken before a shaft is put down. The property is one of the largest in the field, comprising 561 acres lying south of the Hunton-Kirkland. At the Goodfish the shaft is down 80 ft. in good ore.

COBALT.—The Nipissing during January mined ore of an estimated net value of $139,622, and shipped bullion from Nipissing and custom ores of an estimated net value of $364,579. The output was smaller than usual owing to the mill having been closed down for the annual clean up. The La Rose Consolidated has declared a dividend of 10%. The profit shown by the annual statement was $126,088. The ore milled amounted to 36,365 tons, yielding 570,969 oz. of silver. The surplus was $551,190. A number of the shareholders are dissatisfied with the management, concerning which a somewhat acrimonious controversy is in progress, and a struggle for control at the approaching annual meeting is anticipated. The Genesee has been unwatered, and a campaign of exploration will shortly be begun. High-grade ore has been encountered on the shaft of the Victory at a depth of about 300 ft., where the vein has widened to 6 in., some of the ore running 2,000 oz. to the ton. Prospectors are giving some attention to the area lying between Cobalt and South Lorrain in the expectation that it may contain silver ore deposits.

VANCOUVER, B.C.

March 10.

LEAD AND ZINC.—At a banquet given by the Associated Boards of Trade of Eastern British Columbia, at Nelson, recently, J. J. Warren, president of the Consolidated Mining & Smelting Company, stated that his company had completely sold out its stock of lead and greatly reduced its surplus of zinc, Japan and China being the principal purchasers. Continuing, he said that metallurgical conditions had been so improved at Trail that, despite the low prices of lead and zinc, the company feared competition from no one, and would start immediately to enlarge its lead refinery from the present capacity of 90 tons to 150 tons of refined lead daily. Moreover, in a short time the company would be in a position to pay for a reasonable percentage of the zinc content of silver-lead-zinc ores received, instead of penalizing that metal, as has been the previous practice.

While Mr. Warren's announcement was received with considerable enthusiasm, it was thought that it may have been forced by a somewhat similar announcement made by Fred W. Bradley, president of the Bunker Hill & Sullivan Mining & Concentrating Company. For some time past this company has been making a bid for the smelting of the Kootenay silver-lead ores, and, as a matter of fact, despite the longer railway haul, recently has been getting most of the output of the district. Early in January Mr. Bradley announced that the company would start at once on the erection of a differential flotation plant and an electrolytic zinc plant, for the purpose of treating the medium-grade zinc-lead-silver ores of the Cœur d'Alene and the Kootenay districts.

CARIBOO.—Present indications point to the probability of a marked revival of placer mining in the Cariboo district this year. Though weather conditions probihit the commencement of prospecting much before the middle of April, more than a hundred prospectors have assembled in the vicinity of Cedar Creek, where the new discovery was made last autumn, and two companies are shipping in machinery for active mining operations. The discovery claim has been bonded to a New York syndicate for, it is said, $200,000, and the initial payment has to be made on April 15. In the event of the payment not being made, which seems hardly likely considering that three car-loads of machinery and supplies have been shipped to the claim, another syndicate is prepared to take up the bond and to make a substantial cash payment.

The Peace River Gold Dredging Company, which absorbed the Ingenika Mining Company, has shipped eight carloads of machinery, including a dredge, to Spirit River, whence it is being hauled in sleds to the company's property, near Hudson's Hope. The company owns 14 miles of dredging leases on the Peace River, above Hudson's Hope canyon, and has thoroughly explored the property during the last two seasons.

PREMIER MINE.—According to the *Portland Canal News*, which is published at Stewart, approximately 6,000 tons of ore and concentrate were shipped from Stewart by the Premier Gold Mining Company during the first six weeks of the year. The tramway is delivering ore faster than it is possible to get ships to carry it away, and it had to be stopped for a few days, as the ore-bunkers were full. The Premier is now shipping medium-grade ore, valued at about $50 per ton, to Anyox, and high-grade and concentrate to Tacoma. More men have been employed at the mine, the pay-roll now containing 430 names. The President of the company paid a visit to the mine recently, and bonded a few claims in the vicinity of the company's property.

YUKON.—Several new discoveries of rich silver-lead veins are reported by recent arrivals from Keno Hill. Rich veins have been opened on the Crœsus, Crystal Gulch, Gambler Gulch, Slate Creek, and Stone claims. The Slate Creek Company is mining a 5 ft. lode of almost clean, steel-grey galena.

The Yukon Gold Company will ship more than 3,000 tons of ore from the No. 9 vein, on its Rico claim. The company has reached a depth of 300 ft., and the ore is said to be rich and the lode as large as at the surface. The company is mining another vein on the same claim, but a mile away, and is in high-grade ore at a depth of 70 ft. The ore from these veins runs between 200 and 500 oz. of silver per ton and from 40 to 65% of lead.

The Treadwell interests have confined themselves to development, and have blocked out a large tonnage of ore on the McQuest-Cyclop claims. Two shafts have been sunk to a depth of 100 ft., and are to be continued to 300 ft., and connected by three levels. The vein averages 3 ft. in width in both shafts, and assays run from two to five hundred ounces in silver per ton.

PERSONAL

C. A. BANKS is here from British Columbia.

W. E. BARRON, late of Rhodesia Broken Hill, has started practice as a consulting mining and metallurgical engineer, and is at present examining tin properties in South-West Africa.

W. B. BLYTH is home from Venezuela.

S. C. BULLOCK and E. D. O'BRIEN have left for the Araguaya River district, Brazil.

J. T. DIXON, of Inder, Henderson, & Dixon, has left for Colombia.

ARTHUR S. DWIGHT is the new president of the American Institute of Mining and Metallurgical Engineers.

W. R. FELDTMANN has left for West Africa.

W. H. GOODCHILD has gone on a short visit to Burma.

E. C. B. HEDEN has joined the staff of the *Chemical Engineering and Mining Review*, of Melbourne.

HARLEY E. HOOPER has relinquished the position of lecturer in mining at the Melbourne School of Mines to accept that of Principal of the Bairnsdale School of Mines, Victoria.

AUBREY E. HORN is home from Nigeria.

J. P. HUTCHINS has been in Paris and is now in Berlin on business.

ARTHUR E. LEWIS is expected shortly from Perak.

ELIOT T. LEWIS, manager for the Tongkah Harbour Tin Dredging Co., Siam, has been visiting Australia to confer with the board.

FRANK LUSH has left for Nigeria.

H. F. MARRIOTT has returned from the Rand.

E. P. MATHEWSON arrived at San Francisco on March 13, on the conclusion of his visit to Burma.

F. P. MENNELL is investigating coal prospects in Tanganyika territory.

P. G. MORGAN, Director of the New Zealand Geological Survey, is making an examination of the Waihi goldfield.

L. M. PARSONS, a past student of the Imperial College of Science and Technology, has received the degree of D.Sc. (London), for a thesis on Dolomitization in the Carboniferous Limestone of the Midlands.

(*Continued on next page.*)

F. W. PAYNE has left on a short visit to the East.

V. B. POWIS has been appointed one of the three joint managing directors of the Niger Company.

C. W. PURINGTON was at Vladivostok during January and February and has returned to Yokohama.

F. G. A. ROBERTS is here from the Rand on holiday.

Sir HENRY STRAKOSCH has returned from South Africa.

H. LESLIE SWIFT is back from Nigeria.

J. W. TEALE, of Bainbridge, Seymour & Co., has returned from Brazil.

F. W. THOMAS, managing director of Williams, Harvey & Co., Ltd., has left for the United States.

W. H. TREWARTHA-JAMES has left for South America.

A. JOSHUA, who was a member of the board of the Great Boulder Proprietary for many years, died on March 25.

BENJAMIN MAGNUS, for some years connected with the Mount Morgan mine, died an March 13 at Poughkeepsie, New York.

HENRY RICHARDS, for many years secretary of the Stratton's Independence, and later of Oroville Dredging and Lena Goldfields, died on March 28.

JAMES MARSHALL, chairman and managing director of Marshall, Sons, & Co., Ltd., Gainsborough, died on February 27, in his 86th year.

ARTHUR FERLAND, of Haileybury, Ontario, died on February 7, at the age of 67. He was one of the original stakers of the Nipissing mine, Cobalt.

DR. J. C. BRANNER, at one time President of Leland Stanford University, died last month. His name is known on this side as an authority on the geology of Brazil.

Dr. J. T. MERZ died on March 21, at Newcastle-on-Tyne, in his 82nd year. He was at one time technical manager for the Tharsis Sulphur & Copper Company, but he was perhaps better known as a pioneer in the introduction of electric light and power, particularly in the North of England. He was the father of C. H. Merz, a distinguished electrical engineer.

JOHN BALLOT died at New York on April 2 after a long illness. To the present generation he is known as the leading figure in the organization and application of the Minerals Separation froth-flotation process of concentration, and as a co-patentee with Messrs. Sulman & Picard in the principal patent 7,803 of 1905 in this country and 835,120 in the United States. In earlier years he was prominent in South African mining affairs, where he proved himself a capable mining man and geologist. Many of his writings in the old days on these subjects were published under the pseudonym of "Iones Beta."

PHILIP ARGALL died at Denver on March 19, in his 68th year. He was a native of Ireland and his first mining work was done there. Subsequently he went to New Zealand and Mexico, and in 1887 to Colorado, which was his headquarters thereafter. He was a pioneer of the cyanide process in the United States, and built the first large cyanide plant at Cripple Creek. Among the many mines with which he was associated were Stratton's Independence, Golden Cycle, and Dolores. He contributed two important papers to the MAGAZINE, on Metallurgy at Stratton's Independence and the Zinc-Carbonate Ores of Leadville respectively.

TRADE PARAGRAPHS

OLDHAM & SON, LTD., of Denton, Manchester, are putting on the market an electric cap-lamp for miners.

The WESTINGHOUSE BRAKE & SAXBY SIGNAL CO., LTD., of 82 York Road, King's Cross, London, send us a pamphlet describing their electro-pneumatic decking plant at the Thurcroft Main Colliery, Rotherham.

The WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, of East Pittsburgh, U.S.A., send us particulars of a successful test of a double-gap section insulator with switch, made at a mine of the Westmorland Coal Company near Pittsburgh.

The GANDY BELT MANUFACTURING CO., LTD., of Seacombe, Cheshire, send us their latest catalogue relating to the Gandy belt, which contains full details of its uses and applications. To the mining engineer, the belt is of interest not only as a transmitter of power, but also as a conveyor of minerals and ores.

ACKROYD & BEST, LTD., of the Beacon Works, Morley, Yorkshire, send us an elaborate catalogue of their mine lamps and accessories. Some of the lamps are the safety lamps using oil or benzine, and others are electric lamps. A special feature of these lamps is the means for preventing their unauthorized opening.

ROPEWAYS, LTD., of Eldon Street House, South Place, London, E.C. 2, having acquired a large stock of new standard ropeway material suitable for prospecting and light haulage work up to 10 tons per hour, are now offering this for sale at reduced prices to effect quick disposal. Particulars are given in an advertisement in this issue.

The BUCYRUS COMPANY, of Chicago (London office: Iddesleigh House, Caxton Street, S.W. 1) have a drag-line excavator at work on the site of the British Empire Exhibition at Wembley Park. On March 28 an influential gathering witnessed a special demonstration of the work of this machine in the excavation of the soil and clay in preparing the great sports arena.

NOBEL INDUSTRIES, LTD., of Nobel House, Buckingham Gate, London, S.W. 1, send us a pamphlet giving details of the company and its associated companies and the range of their products. The products include military, mining, and sporting explosives, industrial collodions, thermit welding apparatus, refractory and non-ferrous metals, accumulators, carburettors, stoves and lamps, bicycles, incandescent mantles, leather cloth, etc.

The NORDBERG MANUFACTURING CO., of Milwaukee, U.S.A., send us pamphlets relating to their machines used in mining, namely hoists, air-compressors, and uniflow steam engines. This company has a fine record for supplying plant of this description to big copper and lead mines, such as the Utah Copper, Nevada Consolidated, Inspiration, Ray, Chino, Cananea, Bunker Hill & Sullivan, United Verde, U.V.X., Copper Queen, and Braden.

The GENERAL ELECTRIC CO., LTD., of Magnet House, Kingsway, London, W.C. 2, send us particulars of their flame-proof mining-type boxes for electric lighting. These junction-boxes are for use with wire-armoured V.I.R. cables for lighting in fiery mines, explosive factories, and similar dangerous places, and it is difficult to design such boxes as to comply with regulations and demands. These boxes are constructed in such a way, however, as to meet all requirements by the use of only three standard forms of box and three types of glands.

HADFIELDS, LTD., of Sheffield, have issued their report and balance-sheet for the year 1921. The profit was £158,157, as compared with £107,856 the year before. The dividend was at the rate of 5%, absorbing £79,000, and £69,700 was paid as interest on the debentures created in 1920. The organization of the company's business in the United States as the Hadfield Penfield Steel Company has not yielded any profit so far owing to the depressed condition of trade there, but there are now signs of an improved demand.

The MERRILL COMPANY, of 121, Second Street, San Francisco, send us a new pamphlet relating to their special metallurgical processes plant and materials, namely: The Merrill, or Merco, precipitation process, the Crowe vacuum-zinc shavings process, the Merrill sluicing clarifying filter, the Merco-Nordstrom plug valve, and merrillite. The processes are fully described and illustrated, and records are given of costs at a number of mines. The company's latest novelty is the "Silver" process for graphitic ores. Reference is made to this process elsewhere in this issue.

The HARDINGE COMPANY, of New York (London Office: 11, Southampton Row, W.C. 1), have been appointed agents here for the Tyler "Hum-mer" electrically vibrated screen, made by the W. S. Tyler Co., of Cleveland, Ohio. They send us Catalogue No. 42, describing this screen. The feature of the screen is that an intense vibration is caused by an electro-magnet. It has been largely used in conjunction with the Hardinge mill in dry grinding work, as in cement plants. A number of installations have been erected over here for screening coal, cement, chemicals, and sugar.

The VICTORY PIPE JOINT CO., LTD., of 28, Victoria Street, London, S.W. 1, send us their latest catalogue and price list of their "Victaulic" joints, which are made for pipe-joints from ¾ in. to 72 in. diameter and for pressures from vacuum to 10,000 lb. per sq. in. This joint is the invention of Professor H. S. Hele Shaw and E. Tribe, and is now being widely used in place of the usual joint. It is applicable at mines in connexion with steam, air, and water pipes. The company also send us a long list of pipe and tube manufactures, who supply pipes with ends to suit the "Victaulic" joint.

The METROPOLITAN-VICKERS ELECTRICAL CO., LTD., of Trafford Park, Manchester, have issued their report for the year 1921. The profit was £337,104, and with £58,823 brought forward, the available balance was £395,926, as compared with £359,579 the year before, which sum included £51,089 brought forward. The sum of £35,000 has been written off for depreciation and £100,000 has been placed to reserve. The dividend on the ordinary shares was at the rate of 12½%, the same as that for 1920. The company send us their "Girl" wall-calendar for the twelve months April, 1922, to March, 1923. Both the girl and the calendar are as beautiful as ever.

The *Edgar Allen News*, published monthly by EDGAR ALLEN & CO., LTD., of the Imperial Steel Works, Sheffield, contains in the April number a number of items of interest to mining men. Note is made that the "Air-hardening" high-speed steel is now known as the "Stag-brand air-hardening," the addition being necessary, for though "air-hardening" was registered as a trade mark as long ago as 1882, the words have gradually become a generic term, and it is necessary to specify the brand more closely. The word "Stag" is already well-known in connexion with other manufactures of this firm, for instance, the Stag rock-breaker. Details are given of the shipment of the first plant to France for the working of the new Basset process for making steel direct from ore. Particulars are also given of a giant circular saw 100 in. diameter and ⅜ in. thick, with diamonds mounted in the periphery, to be used in cutting stone. This will cut through a stone slab 6 ft. by 3 ft. in 15 minutes. The company also send us a new pamphlet relating to the high-speed steels to which reference is made above. This pamphlet gives full details of their many applications. It is of interest that these brands of steel are largely used in the United States.

METAL MARKETS

COPPER.—At the beginning of March values of standard copper on the London market had an advancing tendency, but subsequently easiness set in, with the result that prices showed a loss on the month. The general position underwent no change worthy of remark. English consuming demand continued restricted, as was natural in view of the poor commercial situation, the aspect of which was further depressed by the lock-out declared in the engineering trades. Business with the Continent was comparatively quiet, as although France showed a little interest, German buying both here and in America fell away, not only on account of the renewed fall in the mark exchange, but also because of the fact that she had apparently satisfied her needs for the time being. The outlook in the United States was hardly brighter than on this side of the Atlantic; the month opened with firm markets, and the price of electrolytic was pushed up to 13 cents or slightly over. The rise, however, was not sustained, being somewhat artificial, and in the absence of serious buying by either domestic or foreign consumers, the quotation fell away again. Doubts are still expressed as to whether the resumption of operations by the various American mines which have restarted will not prove to be premature, and there is certainly some ground for this view in the present state of the copper markets.

Average price of cash standard copper: March, 1922, £59 6s. 2d.; February, 1922, £60 6s. 1d.; March, 1921, £67 13s. 3d.; February, 1921, £71 0s. 9d.

TIN.—Prices on the standard tin market in London fluctuated moderately during the past month, but the close reflected very little actual change. The market did not present a very brilliant aspect during the period under review. Demand from the Welsh tinplate works was rather quiet, owing to the uncertain outlook for that industry, and Continental purchases were also none too brisk. The brightest spot was the United States, whose tinplate works are operating on quite an active scale; but the London market received little support on this account, as American requirements had been pretty fully satisfied by heavy purchases direct in the East; while, furthermore, the Americans evinced little desire to assist prices on the London market if it could possibly be avoided. As regards the East, the Straits made quite good sales, and Batavia was also a seller at

Daily London Metal Prices: Official Closing
Copper, Lead, Zinc, and Tin per Long Ton

	Copper				
	Standard Cash	Standard (3 mos.)	Electrolytic	Wire Bars	Best Selected
Mar.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.
10	60 5 0 to 60 7 6	61 2 6 to 61 5 0	67 0 0 to 68 0 0	67 10 0 to 68 0 0	64 0 0 to 66 0 0
13	60 10 0 to 60 15 0	61 10 0 to 60 12 6	67 0 0 to 68 0 0	67 10 0 to 68 0 0	— —
14	60 12 6 to 60 15 0	61 12 6 to 61 15 0	68 0 0 to 69 0 0	68 10 0 to 69 0 0	64 0 0 to 66 0 0
15	60 5 0 to 60 7 6	61 5 0 to 61 17 6	67 15 6 to 68 15 0	68 5 0 to 68 15 0	— —
16	60 5 0 to 60 7 6	61 2 6 to 61 5 0	67 10 0 to 68 10 0	68 0 0 to 68 10 0	— —
17	60 0 0 to 60 2 6	60 17 6 to 61 0 0	67 10 0 to 68 10 0	68 0 0 to 68 10 0	64 0 0 to 66 0 0
20	59 10 0 to 59 12 6	60 7 6 to 60 10 0	67 5 0 to 67 15 0	67 5 0 to 67 15 0	— —
21	59 2 6 to 59 5 0	60 0 0 to 60 2 6	66 15 0 to 67 15 0	67 5 0 to 67 15 0	63 0 0 to 65 0 0
22	58 5 0 to 58 7 6	59 2 6 to 59 5 0	66 0 0 to 67 0 0	66 15 0 to 67 0 0	— —
23	58 5 0 to 58 7 6	59 2 6 to 59 5 0	65 0 0 to 66 10 0	66 5 0 to 65 10 0	— —
24	57 12 6 to 57 15 0	58 10 0 to 58 12 6	64 10 0 to 66 0 0	65 15 0 to 66 0 0	63 0 0 to 65 0 0
27	58 2 6 to 58 5 0	59 0 0 to 59 2 6	64 5 0 to 65 15 0	65 10 0 to 65 15 0	— —
28	58 0 0 to 58 2 6	58 17 6 to 59 0 0	64 10 0 to 66 5 0	66 0 0 to 66 5 0	62 10 0 to 64 10 0
29	57 12 6 to 57 15 0	58 10 0 to 58 12 6	64 0 0 to 66 0 0	65 15 0 to 66 0 0	— —
30	57 17 6 to 58 0 0	58 12 6 to 58 15 0	64 0 0 to 66 0 0	65 15 0 to 66 0 0	— —
31	57 12 6 to 57 15 0	58 7 6 to 58 10 0	63 10 0 to 65 10 0	65 5 0 to 65 10 0	62 0 0 to 64 0 0
Apr.					
3	57 2 6 to 57 5 0	57 17 6 to 58 0 0	62 10 0 to 64 10 0	64 5 0 to 64 10 0	— —
4	57 2 6 to 57 5 0	57 17 6 to 58 0 0	62 10 0 to 64 10 0	64 5 0 to 64 10 0	61 0 0 to 63 0 0
5	58 2 6 to 58 5 0	58 15 0 to 58 17 6	62 10 0 to 64 10 0	64 5 0 to 64 10 0	— —
6	58 7 6 to 58 10 0	59 2 6 to 59 5 0	63 10 0 to 65 0 0	65 5 0 to 65 10 0	— —
7	58 17 6 to 59 0 0	59 12 6 to 59 15 0	64 10 0 to 66 10 0	66 5 0 to 66 10 0	63 10 0 to 64 10 0

times. China was inclined to hold aloof, probably on account of exchange considerations. Towards the end of the month, sentiment became a little more favourable in anticipation of an improvement in the statistical position. Both dealers and consumers recognize that present quotations are remarkably cheap, but while supplies, both visible and invisible, continue to loom over the market, they are little inclined to commit themselves to any substantial degree.

Average price of cash standard tin: March, 1922, £143 5s.; February, 1922, £149 19s. 6d.; March, 1921, £156 4s. 7d.; February, 1921, £166 9s. 1d.

Lead.—After two weeks of fluctuating but on the whole steady markets, values experienced an upward spurt about the middle of March. Subsequently, prices eased off a little, but on balance an advance was recorded on the month. The sharp rise was due to an influx on Continental inquiry, which probably was inspired by fears in that quarter that supplies from Spain might be cut off by the labour troubles there. In addition, consuming demand in England was not altogether unsatisfactory. The reappearance of a substantial backwardation during the month seemed to indicate that holding interests had regained a certain amount of control over the market. The policy of consumers in buying metal mainly for early delivery naturally assists holders to maintain a comparatively reserved attitude, and is, of course, largely responsible for the premium which early delivery commands over forward. Arrivals of fresh metal into the United Kingdom continued comparatively large, and there is reason to think that some lead must have accumulated in various quarters here. The outlook seems to be in favour of rather smaller arrivals, however, especially from Australia. Spain will probably ship moderate quantities again when the labour trouble there has subsided, but, of course, that country sends a large proportion of its output to its Continental neighbours, so that the London market will not be affected very seriously whatever policy producers there adopt. America has latterly not shipped much metal to the United Kingdom, but still appears to be supplying the Continent. Big lines of metal have been coming in from Australia and Burma, but labour unrest and better demand in the East bids fair to cut down future shipments from those countries.

Average price of soft pig lead: March, 1922, £21 3s.; February, 1922, £20 12s. 10d.; March, 1921, £19 2s. 9d.; February, 1921, £21.

Spelter.—Values advanced on the London spelter market during March, but the rise was not maintained in full. A moderate gain, however, was registered on the month. It was interesting to note that at the highest point of the advance, the contango ceased to exist, doubtless owing to the good demand from galvanizers which was manifest for prompt metal. Consuming interest was very spasmodic, however, and while on some days the turnover on 'Change was considerable, on others idle markets were seen. Professional activity was also not very prominent, although a little was evident at times. Producing countries showed little change in their policy. Silesian spelter is practically off the London market, and although fair lines of Belgian metal continue to come in on account of old contracts, makers in the latter country do not appear to find the present level of London quotations sufficiently remunerative to encourage them to offer eagerly. The outlook, however, is in favour of larger world production, and as any serious rise in London prices or in the sterling exchange with America would doubtless bring out offers from the United States, it seems that these factors will tend to keep prices in check.

Average price of spelter: March, 1922, £25 10s. 5d.; February, 1922, £24 9s. 9d.; March, 1921, £25 10s. 5d.; February, 1921, £25 5s. 5d.

Zinc Dust.—Prices have kept very steady: Australian high-grade £50, American 92 to 94% £47 10s., and English 90 to 92% £45 per ton.

Antimony.—Quotations for English regulus have been reduced, ordinary brands being now £29 5s. to £33 per ton and special brands £32 10s. to £25. Foreign is steady at £24 to £24 10s. in

Prices on the London Metal Exchange.
Silver per Standard Ounce ; Gold per Fine Ounce.

Lead: Soft Foreign	Lead: English	Zinc (Spelter)	Standard Tin: Cash	Standard Tin: 3 mos.	Silver: Cash	Silver: Forward	Gold	
£ s. d. £ s. d.	£ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	d.	d.	s. d.	Mar.
20 15 0 to 20 12 6	22 5 0	25 10 0 to 25 10 0	145 0 0 to 145 5 0	147 0 0 to 147 5 0	33⅜	33½	95 0	10
20 17 6 to 20 15 0	22 5 0	25 12 6 to 25 12 6	143 0 0 to 143 2 6	144 17 6 to 145 5 0	33[illegible]	33⅛	95 9	13
21 0 0 to 20 17 6	22 5 0	25 12 6 to 25 12 6	142 15 0 to 143 0 0	144 10 0 to 144 15 0	33¼	33	96 9	14
21 12 6 to 21 10 0	22 15 0	25 12 6 to 25 12 6	143 12 6 to 143 17 6	145 12 6 to 145 15 0	33⅛	32¾	96 4	15
22 0 0 to 21 17 6	23 5 0	26 0 0 to 26 0 0	143 0 0 to 143 5 0	145 0 0 to 145 5 0	33¼	33	95 11	16
21 12 6 to 21 7 6	22 15 0	25 15 0 to 25 17 6	143 7 6 to 143 10 0	145 5 0 to 145 10 0	33⅜	33⅛	95 9	17
21 12 6 to 21 7 6	22 15 0	25 15 0 to 25 17 6	143 10 0 to 143 15 0	145 5 0 to 145 10 0	33[illegible]	33¼	94 9	20
21 15 0 to 21 10 0	22 15 0	25 15 0 to 25 17 6	143 7 6 to 143 10 0	144 17 6 to 145 2 6	33[illegible]	33⅛	94 9	21
21 12 6 to 21 5 0	22 15 0	25 5 0 to 25 5 0	143 7 6 to 143 10 0	144 17 6 to 145 0 0	33[illegible]	33½	94 8	22
21 2 6 to 20 17 6	22 10 0	25 7 6 to 25 10 0	144 5 0 to 144 10 0	145 15 0 to 146 0 0	33⅜	33¼	94 8	23
21 5 0 to 21 0 0	22 15 0	25 7 6 to 25 10 0	144 7 6 to 144 10 0	145 17 6 to 146 0 0	33½	33[illegible]	94 10	24
21 12 6 to 21 7 6	23 0 0	25 5 0 to 25 7 6	143 12 6 to 143 15 0	145 2 6 to 145 5 0	33⅛	33[illegible]	95 3	27
21 17 6 to 21 10 0	23 5 0	25 12 6 to 25 15 0	142 12 6 to 142 17 6	144 5 0 to 144 10 0	33⅝	33⅛	96 0	28
21 12 6 to 21 5 0	23 0 0	25 12 6 to 25 15 0	143 15 0 to 143 17 0	145 5 0 to 145 7 6	33¾	33[illegible]	95 3	29
21 17 6 to 21 7 6	23 5 0	25 12 6 to 25 15 0	143 0 0 to 143 2 6	144 10 0 to 145 15 0	33[illegible]	33¾	95 3	30
22 0 0 to 21 10 0	23 5 0	25 13 9 to 25 13 9	142 5 0 to 142 10 0	143 15 0 to 144 0 0	34⅛	34	95 0	31
								Ap.
21 15 0 to 21 7 6	23 0 0	25 12 6 to 25 15 0	143 7 6 to 143 10 0	144 17 6 to 145 0 0	33¾	33¾	95 0	3
21 15 0 to 21 5 0	23 0 0	25 12 6 to 25 15 0	143 12 6 to 143 15 0	145 2 6 to 145 5 0	33⅛	33¾	94 9	4
21 17 6 to 21 7 6	23 0 0	26 0 0 to 26 0 0	143 17 6 to 144 0 0	145 10 0 to 145 12 6	33⅛	33⅛	94 9	5
21 17 6 to 21 7 6	23 0 0	26 0 0 to 26 0 0	144 2 6 to 144 5 0	145 15 0 to 145 17 6	33⅝	33⅝	95 0	6
22 0 0 to 21 10 0	23 5 0	26 2 6 to 26 2 6	147 0 0 to 147 5 0	148 5 0 to 148 10 0	33¾	33¾	94 9	7

warehouse for home business, while for substantial export orders the price would be shaded appreciably.

Arsenic.—Values are easy and nominal, Cornish white 99% being priced at £37 per ton, delivered London.

Bismuth.—The price is steady at 9s. to 10s. per lb., according to quantity.

Cadmium.—A moderate business is passing at 5s. 6d. per lb.

Aluminium.—Domestic makers continue to quote £120 for home and £125 for export. Business seems rather quiet. Foreign material is also none too much in demand, the present quotation being about £87 10s. per ton f.o.b. Continent.

Nickel.—The market is dull, and home producers' quotations are easier at £165 per ton for home and export. Continental material is obtainable at about £160 per ton f.o.b. Continent.

Cobalt Metal.—The quotation is easier at 12s. per lb.

Cobalt Oxides.—Values are lower, black oxide being called 9s. and grey 10s. per lb.

Platinum.—Prices are steady, manufactured metal being quoted at £19 and raw at £17 per oz.

Palladium.—Quotations have undergone but little alteration, the price of manufactured being about £16 and raw about £12 per oz.

Quicksilver.—The market has remained fairly steady. At the moment the price is £10 15s. per bottle for spot material. For forward arrival, this price would be shaded.

Selenium.—Powder is steady at 9s. per lb.

Tellurium.—Sellers quote 60s. per lb.

Sulphate of Copper.—The price is rather easier at £27 per ton, for both home and export business.

Manganese Ore.—Indian grades are quoted at 1s. 1d. per unit c.i.f. Caucasian is quiet at 1s. 2d. per unit c.i.f.

Tungsten Ore. — The market is easier, with 65% WO_3 nominal at about 9s. per unit c.i.f. Hamburg.

Molybdenite.—Business is dull ; 85% material is quoted at about 32s. 6d. to 35s. per unit c.i.f.

Chrome Ore.—Indian grades are priced at £4 c.i.f. A fair demand is reported for export, but the home market is quiet.

Silver.—Spot bars were quoted at 32⅝d. on March 1, and after moderate fluctuations firmed up to 33⅜d. on the 10th. Subsequently, the price kept fairly steady at rather below this figure till the closing days of the month, when renewed firmness carried the quotation up to 34⅛d. on March 31. Indian demand was a feature during the month.

Graphite.—The market is quiet and prices are largely a matter of negotiation. We call Madagascar, 80 to 90%, £16 per ton, c.i.f. nominal.

Iron and Steel.—Hopes that the iron and steel trades were at last getting on their feet again, as suggested by the improved demand both at home and abroad for pig iron which characterized that market in February, have been dashed by the two labour disputes now raging. Home consumers having no call for their products have lessened the pig iron demand and steps have had to be taken to curtail output by shutting down two North-Eastern furnaces. Exports, however, are keeping up fairly well, Germany being the principal buyer. Coke prices have weakened owing to this commodity being in less request, but pig iron values are unaffected, present prices being below cost. Consequently, quotations for Cleveland material are firm, No. 3 G.M.B. being offered at 90s. for either home or export consumption. Steel-making iron has fluctuated with the demand, and while the official quotation for East Coast mixed numbers is 100s., home and shipment, business can be done at a little less. Of home consumers, Wales has bought sparingly. As regard the manufactured iron and steel trades, conditions in this branch are far from cheerful. Of course, the engineering and shipbuilding lock-outs are mainly responsible for the depression which exists, home trade buying being almost at a standstill, but overseas buyers still refrain from paying the prices asked in anything like substantial volume. Prices are all unchanged, and at the present time reductions can hardly be looked for.

STATISTICS

PRODUCTION OF GOLD IN THE TRANSVAAL.

	Rand	Elsewhere	Total	Price of Gold per oz.
	Oz.	Oz.	Oz.	s. d.
Total, 1920	7,949,038	204,587	8,153,625	—
January, 1921	637,425	14,168	651,593	105 0
February	543,767	14,370	588,137	103 9
March	656,572	14,551	671,123	103 9
April	665,309	16,073	681,382	103 9
May	671,750	16,026	687,776	103 9
June	663,383	15,107	678,490	107 6
July	673,475	16,080	689,555	112 6
August	695,230	16,296	711,526	111 6
September	674,157	16,939	691,096	110 0
October	690,348	17,477	707,825	103 0
November	688,183	16,053	704,236	102 0
December	664,935	16,912	681,847	95 6
Total, 1921	7,924,534	190,052	8,114,586	—

NATIVES EMPLOYED IN THE TRANSVAAL MINES.

	Gold mines	Coal mines	Diamond mines	Total
December 31, 1920	159,671	14,263	3,340	176,522
January 31, 1921	165,287	14,541	3,319	183,147
February 28	171,518	14,697	1,612	187,827
March 31	174,364	14,906	1,364	190,634
April 30	172,826	14,908	1,316	189,050
May 31	170,595	14,510	1,302	186,407
June 30	168,152	14,704	1,317	184,173
July 31	166,999	14,688	1,246	182,933
August 31	169,008	14,446	1,207	184,661
September 30	171,912	14,244	1,219	187,375
October 31	175,331	13,936	1,223	190,490
November 30	176,410	13,465	1,217	191,092
December 31	177,836	13,280	1,224	192,340

COST AND PROFIT ON THE RAND.

Compiled from official statistics published by the Transvaal Chamber of Mines. Figures for yield include premium.

	Tons milled	Yield per ton	Work'g cost per ton	Work'g profit per ton	Total working profit
		s. d.	s. d.	s. d.	£
January, 1921	1,895,235	35 0	26 3	8 9	829,436
February	1,575,320	35 6	28 6	7 0	550,974
March	1,958,730	34 5	26 1	8 4	813,636
April	1,991,815	34 5	25 10	8 7	854,533
May	1,955,357	35 3	26 2	9 1	889,520
June	1,966,349	35 10	25 10	10 0	979,769
July	2,010,236	37 2	25 7	11 7	1,163,565
August	2,050,722	37 3	25 4	11 11	1,226,282
September	1,997,086	36 8	25 2	11 6	1.151,127
October	2,041,581	34 4	24 9	9 7	981,597
November	2,007.617	34 6	24 9	9 9	978,931
December	1,954,057	31 11	24 11	7 0	683,565

PRODUCTION OF GOLD IN RHODESIA.

	1920	1921	1922
	oz.	oz.	£
January	43,428	46,956	53,541
February	44,237	40,816	51,422
March	45,779	31,995	
April	47,000	47,858	
May	46,266	48,744	
June	45,054	49,466	
July	46,208	51,564	
August	48,740	53,200	
September	45,471	52,436	
October	47,343	53,424	—
November	46,782	53,098	—
December	46,190	55,968	—
Total	552,498	591,525	104,963

TRANSVAAL GOLD OUTPUTS.

	January		February	
	Treated Tons	Yield Oz.	Treated Tons	Yield Oz.
Aurora West	—	—	—	—
Brakpan	—	—	—	—
City Deep	—	—	—	—
Cons. Langlaagte	—	—	—	—
Cons. Main Reef	—	—	—	—
Crown Mines	—	—	—	—
D'rb'n Roodepoort Deep	—	—	—	—
East Rand P.M.	—	—	—	—
Ferreira Deep	—	—	—	—
Geduld	—	—	—	—
Geldenhuis Deep	—	—	—	—
Glynn's Lydenburg	4,030	£7,169§	3,770	£6,635‡
Goch	—	—	—	—
Government G.M. Areas	—	—	—	—
Kleinfontein	—	—	—	—
Knight Central	—	—	—	—
Langlaagte Estate	—	—	—	—
Luipaard's Vlei	—	—	—	—
Meyer & Charlton	—	—	—	—
Modderfontein, New	—	—	—	—
Modderfontein B	—	—	—	—
Modderfontein Deep	—	—	—	—
Modderfontein East	—	—	—	—
New Unified	—	—	—	—
Nourse	—	—	—	—
Primrose	—	—	—	—
Randfontein Central	—	—	—	—
Robinson	—	—	—	—
Robinson Deep	—	—	—	—
Roodepoort United	—	—	—	—
Rose Deep	—	—	—	—
Simmer & Jack	—	—	—	—
Springs	—	—	—	—
Sub-Nigel	—	—	—	—
Transvaal G.M. Estates	16,230	£25,053§	14,355	£25,334‡
Van Ryn	—	—	—	—
Van Ryn Deep	—	—	—	—
Village Deep	—	—	—	—
West Rand Consolidated	—	—	—	—
Witw'tersr'nd (Knights)	—	—	—	—
Witwatersrand Deep	—	—	—	—
Wolhuter	—	—	—	—

‡ £4 10s. 6d. per oz. § £4 13s. 6d. per oz.

RHODESIAN GOLD OUTPUTS.

	January.		February.	
	Tons	Oz.	Tons	Oz.
Cam & Motor	14,661	5,241	14,100	5,036
Falcon	16,088	3,001*	15,004	3,044‖
Gaika	4,258	1,507	3,868	1,386
Globe & Phœnix	6,131	6,657	5,912	5,188
Jumbo	1,300	459	1,350	465
London & Rhodesian	3,695	£3,585	3,752	£3,679
Lonely Reef	5,630	5,193	5,200	4,655
Planet-Arcturus	5,930	2,828	5,730	2,233
Rezende	6,000	2,839	5,500	2,704
Rhodesia G.M. & I.	260	296	246	330
Shamva	59,900	£38,582‡	48,700	£37,729§
Transvaal & Rhodesian	1,600	1,121	—	

* Also 291 tons copper. † At par. Also 283 tons copper.
§ Gold at £4 15s. per oz. ‡ Gold at £4 13s. 9d. per oz.

WEST AFRICAN GOLD OUTPUTS.

	January		February	
	Tons	Oz.	Tons	Oz.
Abbontiakoon	7,200	£13,361*	7,350	£11,759*
Abosso	6,143	2,487	6,600	2,686
Ashanti Goldfields	7,500	8,121	6,161	5,880
Obbuassi	574	742	511	£2,455†
Prestea Block A	7,435	£13,777*	7,033	£14,346*
Taquah	3,170	2,004	2,960	1,911

* At par. † Including premium.

West Australian Gold Statistics.—Par Values.

	Reported for Export Oz.	Delivered to Mint Oz.	Total Oz.	Par Value £
June, 1921	153	28,194	28,347	120,410
July	1,641	44,917	46,558	197,774
August	110	51,731	51,841	220,205
September	380	50,728	51,108	217,092
October	1,910	51,286	53,196	225,959
November	156	46,429	46,585	197,879
December	451	53,348	53,799	228,522
January, 1922	329	37,851	38,180	162,177
February	926	41,194	42,120	178,913
March	180	42,842	43,022	182,745

Australian Gold Outputs.

	West Australia	Victoria	Queensland	New South Wales
				1922
	oz.	oz.	oz.	£
January	51,458	4,587	4,582	11,855
February	27,557	10,940	9,046	12,325
March	47,886	12,383	6,690	—
April	47,273	5,954	2,591	—
May	8,113	10,280	2,077	—
June	28,347	10,431	1,602	—
July	46,558	5,528	1,531	—
August	51,842	8,941	1,413	—
September	51,108	9,113	2,601	—
October	53,197	8,496	1,595	—
November	46,586	7,766	1,356	—
December	53,803	10,752	3,657	—
Total	553,730	104,512	38,741	24,180

Australasian Gold Outputs.

	January		February	
	Tons	Value £	Tons	Value £
Associated G.M. (W.A.)	4,034	5,718‖	5,528	8,129‖
Blackwater (N.Z.)	2,909	5,637*	2,869	5,733*
Gold'n Horseshoe (W.A)	7,788	4,233‡	9,408	5,048‡
Grt Boulder Pro. (W.A.)	7,980	23,940‖	8,274	24,822‖
Ivanhoe (W.A.)	10,055	4,446‡	13,346	5,814‡
Lake View & Star (W.A.)	5,212	8,628‖	5,991	10,728‖
Oroya Links (W.A.)	1,032	6,004‖†	1,716	9,927‖†
South Kalgurli (W.A.)	5,144	9,932‖	6,422	10,586‖
Waihi (N.Z.)	7,674	2,261‡ 10,441§	25,856*e*	7,077‡ 44,079§
„ Grand Junc'n (N.Z.)	—	—	9,280*f*	2,425‡ 8,344§

* Including premium ; † Including royalties ; ‡ Oz. gold ; § Oz. silver ; ‖ At par ; *e*, 8 weeks to March 18 ; *f*, Jan., Feb., March.

Miscellaneous Gold and Silver Outputs.

	January		February.	
	Tons	Value £	Tons	Value £
Brit. Plat. & Gold (C'lbia)	—	285*p*	—	279*p*
El Oro (Mexico)	32,300	186,130†	30,780	176,481†
Esperanza (Mexico)	—	901*e*	—	—
Frontino & Bolivia (C'lbia)	2,010	8,688	1,800	7,488
Keeley Silver (Canada)	—	51,000*s*	—	45,000*s*
Mexico El Oro (Mexico)	13,000	188,200†	12,060	195,060†
Mining Corp. of Canada	—	—	—	—
Oriental Cons. (Korea)	—	71,640†	—	73,700†
Ouro Preto (Brazil)	7,600	2,738‖	6,800	2,558‖
Plym'th Cons. (Calif'rnia	8,500	8,621*	7,000	8,024*
St. John del Rey (Brazil)	—	45,000*	—	59,000*
Santa Gertrudis (Mexico)	32,628	63,541*e*	32,297	58,478*e*
Tomboy (Colorado)	17,700	78,000†	16,000	75,000†

* At par. † U.S. Dollars. ‡ Profit, gold and silver. Oz. gold. *p* Oz. platinum and gold. *s* Oz. silver. *e* Profit in dollars.

Nechi (Colombia): 21 days to February 22, $15,490 from 116,297 cu. yd.; 22 days to March 16, $7,671 from 77,851 cu. yd.

Pato (Colombia): 13 days to February 23, $10,298 from 65,987 cu. yd.; 18 days to March 13, $10,443 from 93,169 cu. yd.

Indian Gold Outputs.

	January		February	
	Tons Treated	Fine Ounces	Tons Treated	Fine Ounces
Balaghat	3,250	2,446	3,000	2,324
Champion Reef	11,894	4,939	10,632	4,965
Mysore	17,565	10,525	17,467	10,519
North Anantapur	550	603	550	601
Nundydroog	9,521	5,039	8,242	4,753
Ooregum	12,900	8,483	15,500	8,168

Production of Gold in India.

	Reported by English mining companies.				Total.
	1918	1919	1920	1921	1922
	Oz.	Oz.	Oz.	Oz.	Oz.
January	41,420	38,184	39,073	34,028	35,493
February	40,787	36,384	38,872	32,529	—
March	41,719	38,317	38,760	32,576	—
April	41,504	38,248	37,307	32,363	—
May	40,889	38,608	38,191	32,656	—
June	41,264	38,359	37,864	32,207	—
July	40,229	38,549	37,129	32,278	—
August	40,496	37,850	37,375	32,498	—
September	40,088	36,813	35,497	32,642	—
October	39,472	37,138	35,023	32,186	—
November	36,984	39,628	34,522	32,293	—
December	40,149	42,643	34,919	32,578	—
Total	485,236	461,171	444,532	390,549	35,493

Base Metal Outputs.

		Jan.	Feb.
Broken Hill British	Tons lead carb. ore	370	—
	Tons lead conc.	2,234	2,805
	Tons zinc conc.	1,810	2,010
Broken Hill Prop.	Tons lead conc.	1,437	1,638
	Tons zinc conc.	5,895	6,464
Broken Hill South	Tons lead conc.	6,234	4,447
Burma Corporation	Tons refined lead	3,202	3,016
	Oz. refined silver	355,573	299,223
Electrolytic Zinc	Tons zinc	3,020†	1,457
Mount Lyell	Tons copper	576	576
	Oz. silver	12,206	16,533
	Oz. gold	345	319
North Broken Hill	Tons lead conc.	1,630	1,750
	Tons zinc conc.	1,590	1,720
Pilbara	Tons copper ore	—	
Poderosa	Tons copper ore	490	560
Rhodesia Broken Hill	Tons lead	1,848	1,735
Sulphide Corporation	Tons lead conc.	2,101	2,106
	Tons zinc conc	3,953	3,425
Tanganyika	Tons copper	3,055	2,624
Zinc Corporation	Tons zinc conc.	8,745	8,255
	Tons lead conc.	722	722

† Period November 22 to February 8.

Imports of Ores, Metals, etc., into United Kingdom.

		Jan.	Feb.
Iron Ore	Tons	193,244	225,939
Manganese Ore	Tons	3,806	6,884
Iron and Steel	Tons	88,727	64,609
Copper and Iron Pyrites	Tons	26,441	19,435
Copper Ore, Matte, and Prec.	Tons	1,309	471
Copper Metal	Tons	6,005	3,237
Tin Concentrate	Tons	2,432	3,034
Tin Metal	Tons	3,147	2,745
Lead, Pig and Sheet	Tons	19,113	15,981
Zinc (Spelter)	Tons	6,908	4,049
Zinc Sheets, etc.	Tons	884	853
Quicksilver	Lb.	105,140	105,448
Zinc Oxide	Tons	241	465
White Lead	Cwt.	8,042	7,775
Barytes, ground	Cwt.	50,851	28,987
Asbestos	Tons	830	666
Phosphate of Lime	Tons	38,516	8,579
Mica	Tons	40	102
Sulphur	Tons	41	7,276
Nitrate of Soda	Cwt.	45,880	124,756
Petroleum: Crude	Gallons	19,225,267	11,740,093
Lamp Oil	Gallons	11,145,846	13,928,360
Motor Spirit	Gallons	25,788,604	23,475,208
Lubricating Oil	Gallons	7,981,430	4,323,828
Gas Oil	Gallons	10,046,813	4,327,187
Fuel Oil	Gallons	22,253,698	35,406,977
Asphalt and Bitumen	Tons	10,226	2,628
Paraffin Wax	Cwt.	55,575	61,041
Turpentine	Cwt.	24,047	14,635

OUTPUTS OF TIN MINING COMPANIES.

In Tons of Concentrate.

	Dec.	Jan.	Feb.
	Tons	Tons	Tons
Nigeria:			
Bisichi	50	33	30
Ex-Lands	—	—	—
Filani	3	1¾	2
Gold Coast Consolidated	2½	3	—
Gurum River	10	9	8
Jos	9	9	10¾
Kaduna	17½	22	20
Kaduna Prospectors	16	15¾	14¼
Keffi Consolidated	25	22	20
Lower Bisichi	4¼	4½	4
Mongu	52	60¼	36¼
Naraguta	70	60	55
Naraguta Extended	22	12	6
Nigerian Consolidated	13¾	10¼	10
N.N. Bauchi	52	50	45
Rayfield	63	37	59
Ropp	125	109	81
Rukuba	4	4	4
South Bukeru	—	12	16
Tin Fields	—	—	—
Yarde Kerri	6	9	11
Federated Malay States:			
Chenderiang	74*	—	-
Gopeng	71½	71½	54
Idris Hydraulic	22	23¾	19½
Ipoh	20¼	21	12¼
Kamunting	71*	—	—
Kinta	41¾	38¾	41¾
Labat	53½	27½	26¾
Malayan Tin	76	68½	74½
Pahang	252	251	230
Rambutan	20	21	18
Sungei Besi	54	36	36
Tekka	36	36	39
Tekka-Taiping	24	21	28
Tronoh	28½	17	25
Other Countries:			
Aramayo Mines (Bolivia)	308	250	234
Berenguela (Bolivia)	42	41	29
Briseis (Tasmania)	—	—	—
Deebook Ronpibon (Siam)	16½	—	29
Leeuwpoort (Transvaal)	85*	—	—
Macreedy (Swaziland)	—	—	—
Renong (Siam)	100½	82	62
Rooiberg Minerals (Transvaal)	—	—	—
Siamese Tin (Siam)	142	103¾	86¾
Tongkah Harbour (Siam)	87	95	82
Zaaiplaats (Transvaal)	—	—	—

* Three months.

NIGERIAN TIN PRODUCTION.

In long tons of concentrate of unspecified content.

Note.—These figures are taken from the monthly returns made by individual companies reporting in London, and probably represent 85% of the actual outputs.

	1917	1918	1919	1920	1921	1922
	Tons	Tons	Tons	Tons	Tons	Tons
January	667	678	613	547	438	473
February	646	668	623	477	270	412
March	655	707	606	505	445	—
April	555	584	546	467	394	—
May	509	525	483	383	337	—
June	473	492	484	435	423	—
July	479	545	481	484	494	—
August	551	571	616	447	477	—
September	538	520	561	528	595	—
October	578	491	625	626	546	—
November	621	472	536	544	564	—
December	655	518	511	577	555	—
Total	6,927	6,771	6,685	6,022	5,618	885

PRODUCTION OF TIN IN FEDERATED MALAY STATES.

Estimated at 70% of Concentrate shipped to Smelters
Long Tons

	1918	1919	1920	1921	1922
	Tons	Tons	Tons	Tons	Tons
January	3,030	3,765	4,265	3,298	3,143
February	3,197	2,734	3,014	3,111	2,572
March	2,609	2,819	2,770	2,190	—
April	3,308	2,858	2,606	2,692	—
May	3,332	3,407	2,741	2,884	—
June	3,070	2,877	2,940	2,752	—
July	3,373	3,756	2,824	2,734	—
August	3,259	2,956	2,786	3,051	—
September	3,157	3,161	2,734	2,338	—
October	2,870	3,221	2,837	3,161	—
November	3,132	2,972	2,573	2,800	—
December	3,022	2,409	2,838	3,435	—
	37,370	36,935	34,928	34,446	5,715

STOCKS OF TIN.

Reported by A. Strauss & Co. Long Tons.

	Jan. 31	Feb. 28	Mar. 31
Straits and Australian Spot	1,823	1,668	1,439
Ditto, Landing and in Transit	745	627	340
Other Standard, Spot and Landing	5,518	5,175	4,990
Straits, Afloat	1,175	875	1,050
Australian, Afloat	75	190	90
Banca, in Holland	5,241	4,766	3,756
Ditto, Afloat	737	600	230
Billiton, Spot	166	100	95
Billiton, Afloat	—	—	—
Straits, Spot in Holland and Hamburg	—	—	—
Ditto, Afloat to Continent	350	500	525
Total Afloat for United States	8,235	8,527	5,437
Stock in America	1,321	1,406	3,086
Total	25,346	24,434	21,040

SHIPMENTS, IMPORTS, SUPPLY, AND CONSUMPTION OF TIN.

Reported by A. Strauss & Co. Long tons.

	Jan.	Feb.	Mar.
Shipments from:			
Straits to U.K.	1,125	875	1,000
Straits to America	4,020	2,255	3,455
Straits to Continent	370	510	530
Straits to other places	50	305	325
Australia to U.K.	210	200	130
U.K. to America	1,639	975	745
Imports of Bolivian Tin into Europe	811	770	1,474
Supply:			
Straits	5,515	3,565	4,985
Australian	210	200	130
Billiton	5	—	10
Banca	1,910	1,038	265
Standard	316	587	706
Total	7,956	5,390	6,096
Consumption:			
U.K. Deliveries	1,897	2,228	2,659
Dutch ,,	144	426	251
American ,,	4,275	3,215	6,030
Straits, Banca & Billiton, Continental Ports, etc.	567	433	550
Total	6,883	6,302	9,490

IMPORTS AND EXPORTS OF GOLD AND SILVER

During February, 1922.

		Imports.	Exports.
Gold:	Unrefined Bullion .... £	2,123,530	—
	Refined Bars .... ,,	276,900	2,682,417
	Coin .... ,,	203	557,143
Silver:	Unrefined Bullion ... oz.	768,803	—
	Refined Bars .... ,,	2,561,652	4,135,233
	Coin .... £	132,057	225,318

OUTPUTS REPORTED BY OIL-PRODUCING COMPANIES.

		Dec.	Jan.	Feb.
Anglo-Egyptian	Tons..	14,039	10,254	13,579
Anglo-United	Barrels	8,302	6,700	4,260
Apex Trinidad	Barrels	17,233	38,799	23,409
British Burmah	Barrels	73,300	71,735	63,450
Caltex	Tons..	17,660	10,443	10,335
Dacia Romana	Tons..	201	304	213
Kern River	Barrels	119,796	110,627	106,075
Lobitos	Tons..	8,821	9,003	8,181
Roumanian Consolidated	Tons..	1,633	1,600	1,616
Santa Maria	Tons..	1,671	12,500*	11,700*
Steaua Romana	Tons .	19,399	18,101	15,600
Trinidad Leaseholds	Tons..	13,250	10,800	8,400
United of Trinidad	Tons..	3,471	3,398	3,486

* Barrels.

QUOTATIONS OF OIL COMPANIES' SHARES.
Denomination of Shares £1 unless otherwise noted.

	Mar. 6, 1922			Apr. 5, 1922		
	£	s.	d.	£	s.	d.
Anglo-American	4	0	0	4	0	0
Anglo-Egyptian B	1	10	0	1	11	0
Anglo-Persian 1st Pref.	1	3	6	1	4	0
Apex Trinidad	1	12	6	1	10	0
British Borneo (10s.)		11	3		8	9
British Burmah (8s.)		15	0		13	6
Burmah Oil	5	10	0	5	13	6
Caltex ($1)		3	0		2	6
Dacia Romano		13	9		12	6
Kern River, Cal. (10s.)	1	0	6	1	2	3
Lobitos, Peru	4	10	0	4	16	0
Mexican Eagle, Ord. ($5)	3	17	6	3	12	6
„ „ Pref. ($5)	3	15	0	3	10	0
North Caucasian (10s.)		15	0		13	6
Phœnix, Roumania		14	0	1	9	0
Roumanian Consolidated		8	0		13	6
Royal Dutch (100 gulden)	35	10	0	39	0	0
Scottish American		2	0		2	6
Shell Transport, Ord.	4	12	6	4	18	9
„ „ Pref. (£10)	8	15	0	9	5	0
Trinidad Central	3	6	0	3	5	0
Trinidad Leaseholds	1	5	0	1	5	6
United British of Trinidad		12	6		11	0
Ural Caspian		15	0		16	0
Uroz Oilfields (10s.)		5	3		7	0

PETROLEUM PRODUCTS PRICES. April 9.

REFINED PETROLEUM: Water white, 1s. 2d. per gallon; standard white, 1s. 1d. per gallon; in barrels 3d. per gallon extra.

MOTOR SPIRIT: In bulk: Aviation spirit, 2s. 6d. per gallon; No. 1, 2s. 2d. per gallon; No. 2, 2s. per gallon.

FUEL OIL: Furnace fuel oil, £3 12s. 6d. per ton; Diesel oil, £5 per ton.

AMERICAN OILS: Best Pennsylvania crude at wells, $3·25 per barrel. Refined standard white for export in bulk, 7 cents per U.S. gallon; in barrels 13 cents. Refined water white for export in bulk, 8 cents per U.S. gallon; in barrels 14 cents.

DIVIDENDS DECLARED BY MINING COMPANIES
During month ended April 10.

Company	Par Value of Shares	Amount of Dividend
Gopeng Consolidated	£1	3d. less tax.
Kern River Oil	10s.	9d. less tax.
Shamva Mines	£1	1s. 6d. less tax.
Nundydroog	10s.	1s. less tax.
Mason & Barry	£1	8s. less tax. Bonus, 2s. tax paid.
Balaghat Gold	Pref. 10s.	9d. less tax.
	Ord. 10s.	9d. less tax.
Grenville United	10s.	4s.*
Amalgamated Zinc (De Bavay's)	£1	1s. less tax.
Globe and Phœnix	5s.	1s. tax paid.

* Distribution of Capital on Liquidation.

PRICES OF CHEMICALS. April 7.

These quotations are not absolute; they vary according to quantities required and contracts running.

		£	s.	d.
Acetic Acid, 40%	per cwt.	1	3	0
„ 80%	„	2	6	0
„ Glacial	per ton	57	0	0
Alum	„	14	0	0
Alumina, Sulphate	„	12	10	0
Ammonia, Anhydrous	per lb.		2	2
„ 0·880 solution	per ton	25	0	0
„ Carbonate	per lb.			4
„ Chloride, grey	per ton	37	0	0
„ „ pure	per cwt.	3	5	0
„ Nitrate	per ton	40	0	0
„ Phosphate	„	75	0	0
„ Sulphate	„	17	0	0
Antimony, Tartar Emetic	per lb.		1	6
„ Sulphide, Golden	„		1	3
Arsenic, White	per ton	37	0	0
Barium Carbonate	„	6	0	0
„ Chlorate	per lb.			7
„ Chloride	per ton	15	0	0
„ Sulphate	„	8	0	0
Benzol, 90%	per gal.		2	3
Bisulphide of Carbon	per ton	50	0	0
Bleaching Powder, 35% Cl.	„	14	0	0
„ Liquor, 7%	„	5	0	0
Borax	„	29	0	0
Boric Acid Crystals	„	60	0	0
Calcium Chloride	„	8	0	0
Carbolic Acid, crude 60%	per gal.		1	10
„ „ crystallized, 40°	per lb.			6
China Clay (at Runcorn)	per ton	4	10	0
Citric Acid	per lb.		2	0
Copper, Sulphate	per ton	27	0	0
Cyanide of Sodium, 100%	per lb.			11
Hydrofluoric Acid	„			7½
Iodine	per oz.		1	0
Iron, Nitrate	per ton	8	0	0
„ Sulphate	„	3	0	0
Lead, Acetate, white	„	41	0	0
„ Nitrate	„	46	0	0
„ Oxide, Litharge	„	33	0	0
„ White	„	40	0	0
Lime, Acetate, brown	„	8	10	0
„ „ grey 80%	„	13	10	0
Magnesite, Calcined	„	20	0	0
Magnesium, Chloride	„	9	0	0
„ Sulphate	„	8	0	0
Methylated Spirit 64° Industrial	per gal.		4	0
Nitric Acid, 80° Tw.	per ton	27	0	0
Oxalic Acid	per lb.			8
Phosphoric Acid	per ton	50	0	0
Potassium Bichromate	per lb.			6½
„ Carbonate	per ton	23	0	0
„ Chlorate	per lb.			5
„ Chloride 80%	per ton	12	0	0
„ Hydrate (Caustic) 90%	„	32	0	0
„ Nitrate	„	43	0	0
„ Permanganate	per lb.			10½
„ Prussiate, Yellow	„		1	3
„ „ Red	„		3	0
„ Sulphate, 90%	per ton	15	0	0
Sodium Acetate	per ton	26	0	0
„ Arsenate 45%	„	38	0	0
„ Bicarbonate	„	12	0	0
„ Bichromate	per lb.			6
„ Carbonate (Soda Ash)	per ton	15	0	0
„ „ (Crystals)	„	6	10	0
„ Chlorate	per lb.			4
„ Hydrate, 76%	per ton	26	10	0
„ Hyposulphite	„	12	0	0
„ Nitrate, 96%	„	15	0	0
„ Phosphate	„	18	0	0
„ Prussiate	per lb.			10
„ Silicate	per ton	11	15	0
„ Sulphate (Salt-cake)	„	4	0	0
„ „ (Glauber's Salts)	„	4	10	0
„ Sulphide	„	22	0	0
„ Sulphite	„	12	10	0
Sulphur, Roll	„	10	10	0
„ Flowers	„	10	10	0
Sulphuric Acid, Fuming, 65°	„	24	0	0
„ „ free from Arsenic, 141°	„	6	5	0
Superphosphate of Lime, [illegible]%	„	4	10	0
Tartaric Acid	per lb.		1	4
Turpentine	per cwt.	3	6	6
Tin Crystals	per lb.		1	3
Titanous Chloride	„		1	0
Zinc Chloride	per ton	22	10	0
Zinc Oxide	„	40	0	0
Zinc Sulphate	„	15	0	0

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD, SILVER, DIAMONDS:

	April 7, 1921	April 5, 1922
	£ s. d.	£ s. d.
RAND:		
Brakpan	2 8 9	2 7 6
Central Mining (£8)	5 15 0	6 8 9
City & Suburban (£4)	6 3	2 6
City Deep	1 18 9	2 2 6
Consolidated Gold Fields	16 3	15 3
Consolidated Langlaagte	11 3	13 9
Consolidated Main Reef	9 6	10 0
Consolidated Mines Selection (10s.)	13 3	12 0
Crown Mines (10s.)	1 15 0	1 16 3
Daggafontein	2 6	2 9
Durban Roodepoort Deep	2 0	4 3
East Rand Proprietary	4 0	6 6
Ferreira Deep	9 6	7 0
Geduld	2 5 0	2 15 0
Geldenhuis Deep	5 6	6 0
Government Gold Mining Areas	3 15 0	4 0 0
Johannesburg Consolidated	1 2 0	1 3 6
Kleinfontein	5 6	6 3
Knight Central	4 0	4 6
Langlaagte Estate	9 6	12 6
Luipaards Vlei	2 0	2 6
Meyer & Charlton	4 0 0	3 7 6
Modderfontein, New (10s.)	3 2 6	3 10 0
Modderfontein B (5s.)	1 3 9	1 8 9
Modderfontein Deep (5s.)	2 1 3	2 2 6
Modderfontein East	10 6	9 0
New State Areas	1 0 0	1 8 9
Nourse	6 0	11 6
Rand Mines (5s.)	2 2 6	2 5 0
Rand Selection Corporation	3 10 0	2 7 6
Randfontein Central	8 6	10 9
Robinson (£5)	8 6	8 6
Robinson Deep A (1s.)	11 3	10 0
Rose Deep	11 3	11 3
Simmer & Jack	2 6	3 6
Springs	1 11 3	1 18 9
Sub-Nigel	11 3	12 0
Union Corporation (12s. 6d.)	15 6	18 0
Van Ryn	10 0	10 3
Van Ryn Deep	3 12 6	3 3 9
Village Deep	7 3	8 6
West Springs	12 6	8 9
Witwatersrand (Knight's)	12 6	12 6
Witwatersrand Deep	7 0	9 6
Wolhuter	4 0	3 3
OTHER TRANSVAAL GOLD MINES:		
Glynn's Lydenburg	6 6	6 3
Transvaal Gold Mining Estates	8 0	7 0
DIAMONDS IN SOUTH AFRICA:		
De Beers Deferred (£2 10s.)	10 5 0	10 0 0
Jagersfontein	2 5 0	2 3 9
Premier Deferred (2s. 6d.)	4 5 0	4 10 0
RHODESIA:		
Cam & Motor	7 6	9 3
Chartered British South Africa	12 0	13 0
Falcon	7 0	3 3
Gaika	8 0	10 0
Globe & Phœnix (5s.)	19 0	10 6
Lonely Reef	1 17 6	2 5 0
Rezende	2 5 0	2 2 6
Shamva	1 8 9	1 10 0
WEST AFRICA:		
Abbontiakoon (10s.)	2 0	2 0
Abosso	8 3	8 0
Ashanti (4s.)	13 6	13 3
Prestea Block A	1 9	1 3
Taquah	8 3	8 0
WEST AUSTRALIA:		
Associated Gold Mines	2 3	6 3
Associated Northern Blocks	2 3	2 3
Bullfinch (5s.)	1 0	1 0
Golden Horse-Shoe (£5)	12 6	11 3
Great Boulder Proprietary (2s.)	5 6	5 0
Great Fingall (10s.)	1 6	1 0
Hampton Celebration	3 9	3 9
Hampton Properties	5 0	4 0
Ivanhoe (£5)	17 6	18 9
Lake View Investment (10s.)	9 3	8 0
Lake View and Star (4s.)	1 6	1 9
Oroya Links (5s.)	1 3	1 3
Sons of Gwalia	4 9	3 0
South Kalgurli (10s.)	6 9	6 0

GOLD, SILVER, *cont.*	April 7, 1921	April 5, 1922
	£ s. d.	£ s. d.
NEW ZEALAND:		
Blackwater	2 6	2 6
Waihi	1 6 3	18 9
Waihi Grand Junction	12 6	5 0
AMERICA:		
Buena Tierra, Mexico	6 3	1 9
Camp Bird, Colorado	4 3	3 0
El Oro, Mexico	9 6	10 0
Esperanza, Mexico	15 0	15 6
Frontino & Bolivia, Colombia	8 9	6 3
Kirkland Lake, Ontario	10 0	14 9
Le Roi No. 2 (£5), British Columbia	2 6	2 6
Mexico Mines of El Oro, Mexico	4 5 0	3 12 6
Nechi (Pref. 10s.), Colombia	7 6	5 0
Oroville Dredging, Colombia	1 2 6	1 3 9
Plymouth Consolidated, California	17 6	5 0
St. John del Rey, Brazil	14 6	16 9
Santa Gertrudis, Mexico	6 0	5 3
Tomboy, Colorado	5 0	8 6
RUSSIA:		
Lena Goldfields	10 0	8 9
Orsk Priority	5 0	5 0
INDIA:		
Balaghat (10s.)	7 3	7 6
Champion Reef (2s. 6d.)	1 9	3 3
Mysore (10s.)	12 6	13 0
North Anantapur	3 9	2 6
Nundydroog (10s.)	5 6	8 6
Ooregum (10s.)	12 6	13 9

COPPER:

	April 7, 1921	April 5, 1922
Arizona Copper (5s.), Arizona	1 5 0	13 9
Cape Copper (£2), Cape and India	15 0	10 0
Esperanza, Spain	5 0	4 6
Hampden Cloncurry, Queensland	5 0	5 0
Mason & Barry, Portugal	1 10 0	2 11 3
Messina (5s.), Transvaal	4 0	3 0
Mount Elliott (£5), Queensland	10 0	15 0
Mount Lyell, Tasmania	12 6	14 6
Mount Morgan, Queensland	11 3	12 6
Namaqua (£2), Cape Province	17 6	1 7 6
Rio Tinto (£5), Spain	25 5 0	26 0 0
Russo-Asiatic Consd., Russia	7 3	9 6
Sissert, Russia	5 0	4 6
Spassky, Russia	12 6	10 0
Tanganyika, Congo and Rhodesia	1 2 6	1 3 9

LEAD-ZINC:

	April 7, 1921	April 5, 1922
BROKEN HILL:		
Amalgamated Zinc	17 6	12 6
British Broken Hill	16 3	1 2 6
Broken Hill Proprietary	1 15 0	1 3 9
Broken Hill Block 10 (£10)	10 0	8 9
Broken Hill North	1 2 6	1 7 6
Broken Hill South	1 5 0	1 7 6
Sulphide Corporation (15s.)	10 0	9 0
Zinc Corporation (10s.)	10 0	9 6
ASIA:		
Burma Corporation (10 rupees)	7 6	4 9
Russian Mining	6 6	4 6
RHODESIA:		
Rhodesia Broken Hill (5s.)	6 3	5 3

TIN:

	April 7, 1921	April 5, 1922
Aramayo Mines, Bolivia	1 12 6	2 2 6
Bisichi (10s.), Nigeria	6 3	5 0
Briseis, Tasmania	2 6	3 3
Chenderiang, Malay	13 0	11 3
Dolcoath, Cornwall	3	6
East Pool (5s.), Cornwall	3 6	3 3
Ex-Lands Nigeria (2s.), Nigeria	1 6	1 6
Geevor (10s.), Cornwall	2 6	2 9
Gopeng, Malay	1 8 9	1 13 9
Ipoh Dredging, Malay	11 3	7 6
Kamunting, Malay	1 7 6	16 3
Kinta, Malay	1 10 0	1 15 0
Lahat, Malay	10 0	7 6
Malayan Tin Dredging, Malay	1 3 9	1 1 3
Mongu (10s.), Nigeria	11 3	8 9
Naraguta, Nigeria	15 0	13 9
N. N. Bauchi, Nigeria (10s.)	1 9	1 6
Pahang Consolidated (5s.), Malay	6 6	5 0
Rayfield, Nigeria	3 0	1 9
Renong Dredging, Siam	1 3 9	18 9
Ropp (4s.), Nigeria	6 0	5 0
Siamese Tin, Siam	2 2 6	1 13 9
South Crofty (5s.), Cornwall	4 9	4 0
Tehidy Minerals, Cornwall	8 9	8 9
Tekka, Malay	15 0	15 0
Tekka-Taiping, Malay	17 6	18 9
Tronoh, Malay	1 2 6	1 5 0

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

In this section we give abstracts of important articles and papers appearing in technical journals and proceedings of societies, together with brief records of other articles and papers; also notices of new books and pamphlets, lists of patents on mining and metallurgical subjects, and abstracts of the yearly reports of mining companies.

SHROPSHIRE LEAD AND ZINC MINES

Lead ores have been worked in Western Shropshire to the south of Minsterley from Roman times. Much mining was also done in the twelfth and thirteenth centuries, and during the first half of the nineteenth century large amounts of lead were produced from the Roman Gravels, Grit, Pennerley, Bog, and Snailbeach mines. After 1880, however, the output gradually fell away, and at the present time barytes is the chief product. In 1916 Sir James Ramsden and others acquired control of an extensive group of old properties with the intention of securing a source of lead during the war, and a company called the Shropshire Mines, Ltd., was formed for the purpose of carrying on the operations. No particulars are issued by this company, but information relating to the district and to present operations is contained in Vol. xxiii of the Special Reports on the Mineral Resources of Great Britain just published. This Memoir is written by Mr. Bernard Smith, who acknowledges his indebtedness for much of the information to Col. J. V. Ramsden, and to Mr. T. C. F. Hall, the company's consulting geologist. From this Memoir it would appear that recent operations have been confined to a comprehensive scheme of exploration, and that no great amount of ore has been discovered. As West Shropshire is a mining district about which little or nothing has been written for many years, we give extensive extracts from the Memoir herewith :—

General Geology.—The lead and zinc mines of the Minsterley and Shelve districts of Shropshire (Figs. 1 and 2) lie to the south of Minsterley, chiefly in an area of Lower Ordovician (Arenig) rocks bordering the western flank of the Pre-Cambrian uplands of the Longmynd. On their western margin the Longmyndian rocks are faulted against a strip of Cambrian shales, ranging north-north-east and south-south-west, which are succeeded westward by the Ordovician rocks with an almost similar strike. The Ordovician rocks, which on the Old Series Geological Map, Sheet 60 S.E., are referred to the Llandeilo Series, were divided by Professor C. Lapworth into (1) an Upper or Chirbury Series, of Bala-Caradoc age ; (2) a Middle or Middleton Series, of Llandeilo age ; and (3) a Lower or Shelve Series, of Arenig age. It is in the latter that the chief occurrences of ore have been found. The rock-sequence, as far as it concerns the present subject, is as follows, in descending order :—

Silurian .	Upper Llandovery Series.	
	Unconformity.	
Ordovician	Chirbury Series.	
	Middleton Series, with Weston Grits and Shales at base.	
	Shelve Series .	Upper Stapeley Ashes.
		Stapeley Ashes and Shales.
		Hope Shales.
		Mytton Beds.
		Stiperstones Quartzite.
Cambrian .	Tremadoc, Shineton Group, Habberley Shales.	

The physical features of the district are closely related to the geological structure, the more resistent beds forming lines of hill and scarp, while the softer beds underlie the valleys and the low ground (see Figs. 3 and 4).

The Ordovician beds, despite the fact that they show complexities in detail, possess a comparatively simple geological structure, dipping west-north-west off the Cambrian shales, which they succeed conformably. The Lower Ordovician rocks, however, are repeated by the occurrence of an anticlinal fold (the Shelve Anticline), which brings the Hope Shales and Mytton Beds to the surface in the west

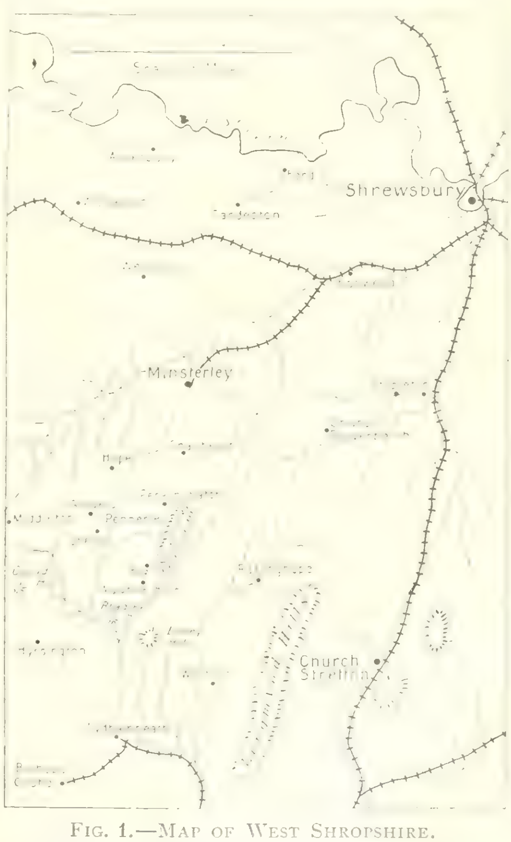


FIG. 1.—MAP OF WEST SHROPSHIRE.
The part enclosed in the rectangle is given in detail in Fig. 2.

after they have sunk beneath a syncline (the Buxton Syncline) in which relics of the Stapeley Ashes occur as isolated outliers. Shelve and Hope are both situated on this anticline, west of which the beds succeed one another in orderly sequence west-north-westward. The result is that the Mytton Beds in particular occur in two outcrops, the eastern having a west-north-west dip off the Stiperstones and beneath the Hope Shales, the western forming an anticline with fairly steep-dipping flanks and a north-north-east pitch. The Ordovician rocks were subjected to these movements and denuded before the deposition of the Silurian rocks which cross their outcrops unconformably. Outliers of the Silurian in the synclinal area, however, suggest that these movements were repeated, to a less extent, at a later date.

Intrusive rocks occur as laccolites, sills, and dykes of basic composition, namely, dolerites or diabases. Some of these are intimately related to the structure of the sedimentary rocks and have risen more or less vertically along strike-faults or lines of weakness produced by strain, or have moved along bedding-planes. They have altered the rocks in their vicinity. These igneous intrusions appear to have been connected, perhaps as an aftermath, with the disturbances that preceded the deposition of the overlying unconformable Silurian Beds. They are closely related in composition to the contemporaneous Ordovician lavas and ashes.

A second period of intrusion seems to be represented by more regular and relatively narrow dykes, which traverse the strata at a high angle on approximately north-west and east-north-east lines. These are quite independent of the above-mentioned structures, and cut across the folds and fractures due to the pre-Silurian movement. In their mode of occurrence they often bear a close resemblance to the mineral veins. Here and there, both veins and dykes are in contact for long distances, in which circumstances the dyke-rocks appear to have undergone alteration to a micaceous substance (sericitization), and are referred to as "white rock" and "rider". The inference is that the dykes are of earlier date than the mineral veins, and occupied the fissures prior to their invasion by the metalliferous solutions. They are probably of Silurian or post-Silurian age.

The author proceeds to refer briefly to the character of some of the sediments.

The Stiperstones Quartzite is, in the main, a well-bedded silicious sandstone or quartzite, forming pronounced ridges and crags, and varying in dip from 45° to 75°. By folding it should approach the surface again beneath Shelve Hill, where its depth is estimated to be 1,200 ft. The upper part is thin-bedded and interlaminated with bands of flagstone, and passes upwards into the Mytton Beds.

The Mytton Beds consist chiefly of massive bands of hard dark grit alternating with flaggy shales, and are often recognizable by the well-marked banded or ribbed structure of the grits. The shaly material becomes more and more predominant upward, till the subdivision finally merges into the succeeding Hope Shales. Lapworth divides the Mytton Beds in descending order as follows: Tankerville Flags and Shales; Gravels and Shelve Church Beds; Ladywell and Snailbeach Grits (Flags) and Shales; Lord's Hill Beds. Although on strictly geological and palæontological grounds the transitional beds —the Tankerville Flags and Shales—are included with the Mytton Beds as Lower Arenig, from the mining point of view they would more suitably be incorporated with the Hope Shales, and in the following account they are frequently referred to this group. The Mytton Beds form high ground and attain their maximum development about the centre of the area, being narrower to the north and thinning away to the south, where they are largely cut out by strike-faults. Folding brings them to the surface again in the anticline of Shelve Hill. The principal mines of the district are situated in these rocks.

The Hope Shales are soft black shale-beds, which cover a large area and form the greater part of the low ground. In places they contain bands of volcanic ash and are often crumpled and folded in detail. They are barren of ores, and represent the Middle Arenig; but some Lower Arenig Beds, as above mentioned, are included, from the point of view of the mining man.

The Stapeley Ashes, which succeed the Hope Shales, are fine-grained volcanic ashes, and volcanic grits and breccias interbedded with shales; they represent the Upper Arenig.

Faults.—The Ordovician rocks are traversed by numerous faults, which can be grouped in two sets:—

(*a*) In one set the fractures trend chiefly north-east or north-west, a marked exception being the north-and-south fault that extends from Round Hill to the neighbourhood of the Bog Mine.

(*b*) In a second set the fractures, with little or no relative displacement of the walls, have a direction a little north of east and south of west. They are of considerable importance in that they are extensively mineralized.

While some of the first set—such as those with the north-north-east direction, which are strike-faults—are evidently connected with the disturbances that antedated the deposition of the Silurian strata, there is reason to believe that much of the faulting in other directions is of post-Silurian date, and is connected with the earth-movements that so profoundly affected this part of the country in late Silurian and early Devonian times. In the result two sets of fractures cross each other at a high angle, a type of fracturing due to compression, and well recognized in many mining districts. The two sets must have been formed almost concurrently, and they intersect, in places, without relative displacement. In general the north-westerly fissures, which break across the pre-Silurian folds, are readily recognized by the abrupt termination of the strata against them, while east-north-east fissures, as stated above, show little relative displacement of the walls.

Since no case has been recorded in which a vein filling a fracture of displacement is faulted out, we may assume that the movements took place previous to mineralization.

The majority of the faults hade in a southerly direction, though many incline to the north. Where two or more parallel fissures hade towards each other, the intervening trough of ground is usually much disturbed and fractured.

The faults are best developed in the harder beds such as the Mytton Grits and Stapeley Ashes, and tend to die out and lose their individuality in the soft shales, where the fissures become filled with a tight plug of crushed material. To this fact we must attribute the barrenness of fractures in these soft beds.

Veins.—The mineral veins, many of which are shown on the Old Series One-inch Geological Map, 60 S.E., obviously occupy fissures, which serve as channels for the circulation of ore-bearing solutions derived from some deep-seated igneous source. [In the present description the terms "vein" and "lode" are used synonymously. No difference of meaning is implied.] They show, however, no connexion with any of the exposed igneous intrusions; probably they are related to a con-

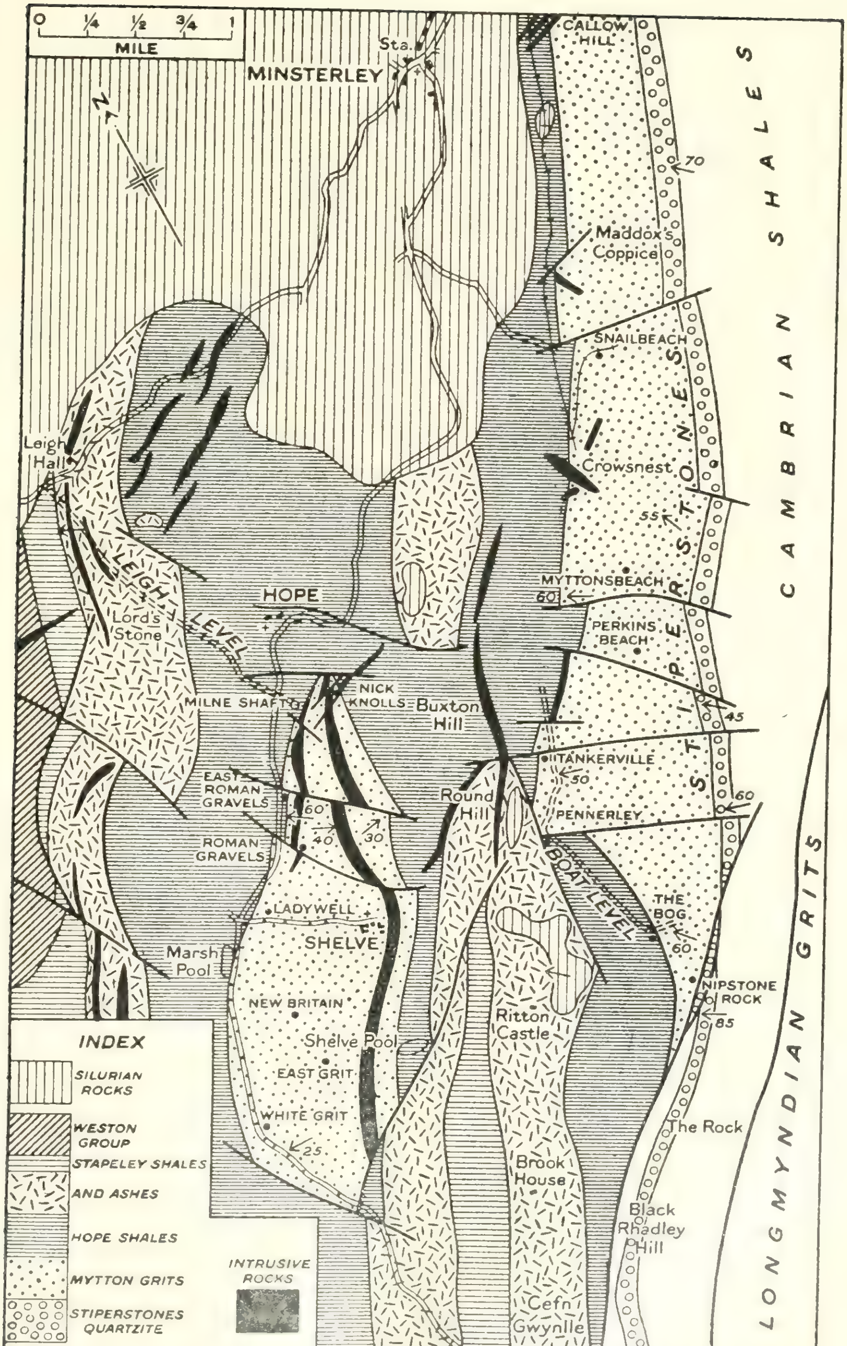


Fig. 2.—Geology of the Minsterley and Shelve District.

TABLE I.—ASSAYS OF SHROPSHIRE LEAD AND ZINC ORES.

Mine.	Percentage of Lead in Ore 1882–1913	Percentage of Zinc in Ore 1882–1913	Silver: oz. per ton of lead-ore 1882–1883
Snailbeach	77–84·5	42–58	0·5
Perkins Beach	70–79	nil	not given
Tankerville	79–83	40–52·5	2·0
Roundhill.	80 [1]	nil	mine not working
Pennerley.	75–80	45–50	2·0
Bog	79–81	40–59	2·16
Rhadley and Rock.	65–80 [2]	nil	mine not working
East Roman Gravels	75–85	40–58	2·5
Roman Gravels.	80–82	40–56	2·23
Grit.	72–73 [3]	48	mine not working

[1] In 1907. [2] In 1888, 1907–8. [3] In 1898–1901.

TABLE II.—ANALYSIS OF GALENA FROM THE NIPSTONE VEIN (BOG MINES).

	%
Lead	82·93
Copper	0·52
Zinc	0·12
Iron	0·07
Sulphur	11·07
Silica	0·70
Calcium oxide	0·75
Alumina	0·05
Barium sulphate	1·45
Tin	0·08
Carbon dioxide (by diff.)	2·26
	100·00

Silver: 2 oz. 5 dwt. per ton of ore.

TABLE III.—ANALYSES OF BLENDE FROM THE BOG MINES AREA.

	No. 1.	No. 2.	No. 3.	Bog.
	%	%	%	%
Lead	1·67	1·60	4·40	3·78
Copper	0·78	0·25	0·28	0·10
Zinc	50·25	39·54	39·97	52·07
Iron	2·92	2·10	3·15	3·16
Alumina	—	—	0·95	0·30
Lime	0·25	0·35	0·50	1·25
Magnesia	0·10	0·10	0·05	0·15
Sulphur	27·58	21·49	22·29	23·89
Insoluble residue:—				
Barium sulphate	8·65	27·50	16·85	6·88
Silica	6·95	5·38	8·97	8·45
Ferric oxide, alumina, and lime	0·98	1·60	2·62	0·43
	100·13	99·91	100·03	100·46

All the samples were free from fluorine.

cealed mass of granite. The main veins appear to occupy fault-fissures, although this cannot be demonstrated in every case. Doubtless they have experienced movement at more than one date, but although the frequent brecciation of their contents points to disturbance after mineralization, they have not suffered the complex sequence of repeated fracturing and mineralization that took place in the Cornish lodes. The mineralization may be regarded as a single episode. Moreover, it is unlikely that fissuring and mineralization are widely separated in time.

While the fractures themselves may extend for a great distance continuously through rocks of several types, it must be strongly emphasized that the ore-bodies are discontinous, and their presence or absence is intimately related to the physical character of the country-rock. A parallel case is the mode of occurrence of the ores in the Llangynog district of Montgomeryshire. In certain kinds of rock—in Shropshire typically represented by the Mytton Grits, at Llangynog by the igneous rocks, and in Flintshire by the massive Carboniferous limestones and cherts—well-defined open fissures, capable of mineralization by circulating waters, are formed; in other rocks, such as the Hope Shales, as explained above, or the Holywell Shales in Flintshire, the walls of the fissures close tightly together. The general effect is relative; rocks suitable as ore-bearers in one district may be comparatively barren in another. Again, in the Mytton Beds themselves, the ore frequently occurs as "shoots" or "floors" in the gritty strata, but is relatively deficient in the interbedded shaly bands.

It is said by the miners that when the veins are traced into the Stiperstones Quartzite they become impoverished or barren, and this receives support from other districts, such as Flintshire and Denbighshire, where veins traced into the sandy part of the Cefn-y-fedw Sandstone appear to pinch out and become unprofitable. In the flaggy top of the Stiperstones, however, ore occurs, here and there, along the bedding-planes, and this has been found to be the case in some of the other rocks also, where differential movement of the strata has left cavities near fault-lines. The infilling deposits are of the nature of flats.

The more important veins have two main trends, corresponding with the main lines of fissuring that influenced the flow of the ore-bearing solutions: (1) N.W. and S.E., and (2) E.N.E. and W.S.W., the latter approximating to east and west. On the whole the solutions seem to do have selected chiefly the east-north-east fissures for their passage, and many of the largest veins in the district are of this trend, possibly because the north-west fractures, by their greater movement, were less easily negotiated. Thus a number of north-west and south-east faults in the main outcrop of the Mytton Beds are barren. In the Shelve Anticline, however, this is not entirely the case. The ideal conditions for maximum deposition of ore occurred at the junction of two fissures, as at the Tankerville and Bog Mines.

As far as can be ascertained, the order in which the rising mineral solutions deposited their contents is as follows: copper ore, zinc ore, and lead ore, and compounds of barium and fluorine. The main zone of copper deposition appears to have lain in the deep-seated Pre-Cambrian rocks, while the deposition of zinc ore, lead ore, and barytes took place in the Ordovician belt above. But while this is the general arrangement, we may note that copper pyrites occurs sporadically in the gangue of the lead veins, as at Tankerville, that at Rorrington the east-and-west veins carry lead above barytes, and that lead occurs occasionally, as at Wrentnall, in the Pre-Cambrian copper zone. The barytes in the Pre-Cambrian rocks is considered to be secondary.

No ore-deposition took place in the Cambrian shales. In the succeeding Ordovician rocks the solutions seem to have been checked by the Hope Shales, and mineralized the Mytton Beds; such solutions as penetrated above the Hope Shales appear to have carried barium with subordinate amounts of lead. The vertical range of the ore-bearing Mytton Beds, where they dip most steeply, is about 2,000 ft., within which compass shoots or ore may be expected to occur, expecially in the gritty beds beneath the base of the Hope Shales. Barytes usually forms a capping to the veins, and in depth gives place to lead, which in turn will be likely to give place downwards to zinc.

The gangue consists chiefly of crushed country-rock with quartz and calc-spar, often in large and well-formed crystals, as at Snailbeach and Tankerville. The gangue often contains barytes and occasionally pyrites and fluor-spar. In most of the lodes the galena and blende lie in irregular strings, which here and there open out into nests of ore.

Analyses and Assays.—The amount of silver occurring with the galena is small, even when compared with that obtained from the ores in the Carboniferous rocks of Flintshire and Denbighshire, in which the silver-content is comparatively low. No values for silver have been returned in the official statistics since 1883; the figures given in Table I are the average returns for the final two years. In the Table the percentages of lead and zinc are the extremes met with during such periods as the mines were in work between 1882 and 1913.

The assays given in Tables II and III are of galena and blende raised in recent years by the Shropshire Mines, Ltd., from the veins in the Bog Mines area.

Recorded Output.—The highest recorded output of dressed lead ore for the whole of Great Britain was for 1856. At that date nine mines were operating in Shropshire, and yielded 4,407 tons 19 cwt. of dressed ore, giving 3,228 tons 15 cwt. of metallic lead. The production in Shropshire rose to its height between 1871 and 1875, since which date it has declined, first rapidly, and then steadily, to the present day. In 1916 only two mines were operating, and yielded but 32 tons of lead ore; and at the present day only a small quantity is obtained, chiefly from the Bog group. The output of Snailbeach is the most important, but shows on the whole a steady decline. The maximum for the district was attained when Gravels, Ovenpipe (Tankerville), Bog, and Pennerley added their maxima to the Snailbeach output.

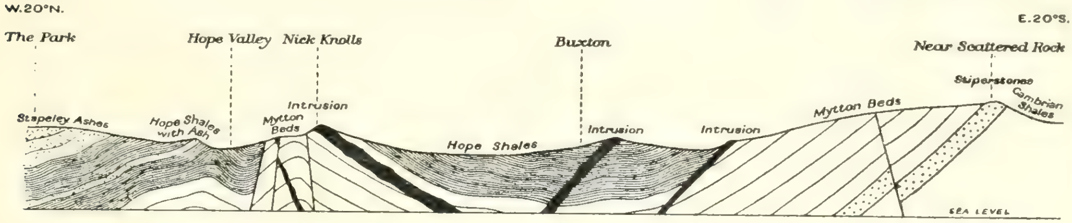


FIG. 3.—SECTION THROUGH THE BUXTON SYNCLINE. (Scale as in Fig. 4.)

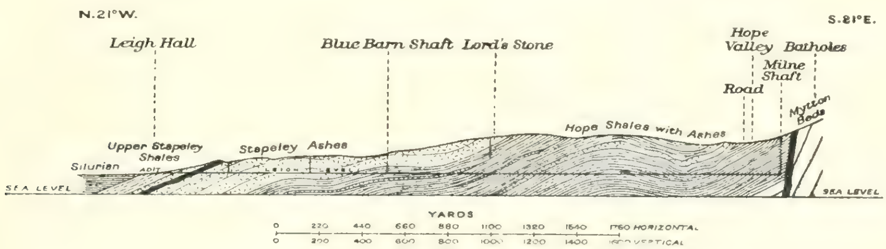


FIG. 4.—SECTION ALONG THE LEIGH LEVEL.

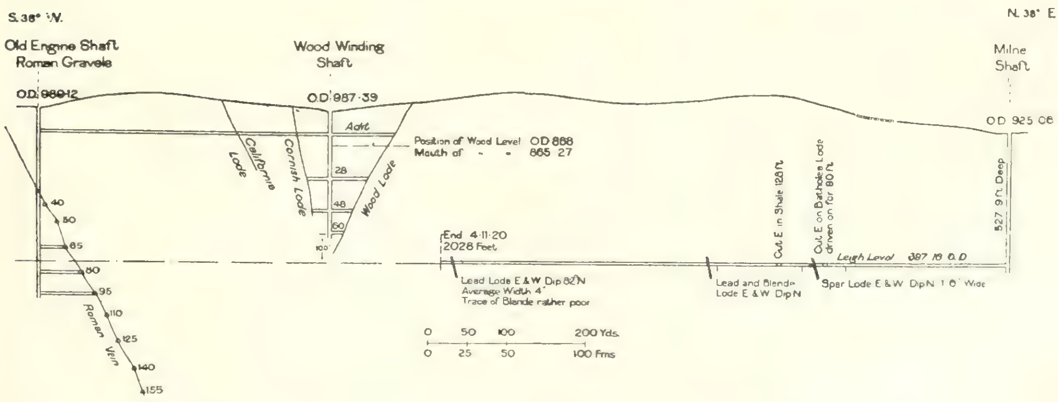


FIG. 5.—SECTION THROUGH ROMAN GRAVELS, WOOD WINDING, AND MILNE SHAFTS.

The highest recorded output of zinc ore for the whole of Great Britain was for 1881. In this year four Shropshire mines were operating, and yielded 197 tons of ore, giving 107 tons of metallic zinc; but the following year gave the maximum for the county, namely, 914 tons of ore. This figure was nearly reached again in 1897, when 880 tons were got. Of late years the output of zinc ore has become relatively more important, and from 1911 to 1914 was greater than that of the galena.

Recent Developments.—The old mines were unwatered by pumping from the deep levels, and also by several long adits, such as the Wood Level in the Shelve Anticline, and the Boat Level in the Tankerville-Bog district, as well as others of shorter length. An extensive scheme, intended to unwater, by a day-adit, the large group of mines situated on the western side of the Shelve Anticline, is now being actively pushed forward by the Shropshire Mines, Ltd.

The adit known as the Leigh Level (Figs. 4 and 5) was commenced many years ago by farmer adventurers. In or about the year 1820 a drainage company (known locally as the Farmers' Company) was formed with a capital of £39,000 to drive a deep drainage-tunnel called the Dingle or Leigh Level, with the intention of draining all the Shelve mines. The tunnel was commenced in 1825; but, after being driven nearly 1¼ miles (actually 5,932 ft.), it was abandoned in 1835, owing to shortage of money following upon lawsuits with Lord Tankerville. The level commences in Brookless Coppice, about 250 yards west of Leigh Hall, and 2½ miles west-south-west of Minsterley, at a height of about 380 ft. O.D., and runs generally in a south-south-east direction (Figs. 4 and 5). There are four shafts upon this first section, the one nearest the forebreast being about 1 chain from Lord's Stone in Lord's Stone Lane. Farther north is the Blue Barn Shaft, about 130 yards south of Blue Barn Cottage and 1,110 yards from tunnel mouth. The tunnel was about 7 ft. high and 5 ft. wide, and had been driven in dead ground. On a plan, with section, of the Rev. J. More's property, dated 1869, a scheme is figured for continuing the tunnel to the Roman Gravels shaft, and thence southward to East Grit Old Engine Shaft.

Recently the Shropshire Mines, Ltd., determined to extend the tunnel, and operations were commenced simultaneously from Blue Barn Shaft and the new Milne Shaft, situated about 700 yards south of Hope Church, and 100 yards north of the old Batholes shaft. The Blue Barn Shaft is 260·7 ft. deep, and the bottom at tunnel-level is 399 ft. O.D. The distance between the Blue Barn Shaft and the Milne Shaft measured along the tunnel, which has several bends, is 2,002 yards, in which distance the level rises by 14 ft. to 413 ft. O.D. The Milne Shaft is 527·9 ft. deep, going down to 397 ft. O.D., its top being at 925·06 ft. O.D. It is a bricked circular shaft of 14 ft. diameter, and will form the chief centre of mining operations, if the driving is successful. At the time of Mr. Smith's visit, in October, 1919, it was being fitted with cages. The section of the tunnel between the Blue Barn Shaft and the Milne Shaft was completed in September 1919, and the tunnel is now being driven south-west in the direction of the Wood Engine Shaft of the East Roman Gravels Mine, which it will enter at 100 ft. below the shaft-bottom, at a point where the Cornish or California and Wood Lodes are supposed to intersect by opposed dip (Fig. 5). By November, 1920, about 2,028 ft. of this section had been driven through shale, greenstone, and Mytton Beds, the total distance from the Milne Shaft to the Wood Shaft being about 820 yards. Thus the length of the tunnel from the mouth to the Wood Shaft is over 3,932 yards. About 1½ miles of further tunnelling would carry it to the Grit Mine.

The hope entertained that this adit would, in the course of driving, open up a large extent of productive ground has not been fulfilled, and could hardly be justified either on geological grounds or from local mining experience, for the ground traversed up to the Milne Shaft is chiefly Stapeley Ash and Hope Shales, well above the usual ore-bearing horizon of the Mytton Beds (Fig. 4). Now that the tunnel is in the ore-bearing beds, it remains to be seen whether the veins it will unwater below the old mine-workings can be made to pay, and whether the new veins cut are productive.

In some cases, again, the level reached by this adit in some of the old mines will be well above that attained by the old workings; hence, pumping-charges will be added to the capital charges of the undertaking. Since, however, the water is chiefly descending surface-water, these costs should not be great. There is no large reservoir of water with a well-marked water-table, like that occurring in many limestone districts.

If a branch from the level were driven from the Hope Valley to the Bog Mine in the eastern outcrop of the Mytton Beds, it would penetrate these beds in the Shelve Anticline also, but only at a level that has already been opened up and worked. Beyond this anticline the greater part of its course would be in the Hope Shales.

The future of the district is, therefore, at the moment of writing, in suspense, owing chiefly to the want of knowledge of the true state of water-logged mines. The tunnel will drain an immense area to a depth of 800 to 1,300 ft. from the surface, according to the profile of the ground. Modern plant, together with mining knowledge and practice, backed by sound geological advice, may produce satisfactory results, even in the case of mines that were abandoned through the apparent poorness of the veins. While there seems good reason for the belief that most of the better known veins have already yielded the greater part of their lead ore, a much greater future production of zinc ore may be expected, since, in some cases, considerable quantities of exposed ore remain, while in others deeper mining should bring rich deposits to light. It might pay to work lead ore in mines that are rich in both barytes and blende.

Since the Mytton Beds are the chief carriers of ore in the district, it has been suggested that capital might be expended profitably in exploring these beds beneath their cover of Hope Shales in the centre of the syncline that separates the two outcrops to the east of the Hope Valley. There is reason to suppose that this virgin ground may prove as productive as that already opened up. North of the Roundhill Mine a shaft sunk through the Hope Shales should enter the Mytton Beds at about 1,000 ft.

The Mines and Workings.—Mr. Smith proceeds to deal with the workings and mines in detail. He divides them into three chief groups. In the western or Hope-Shelve district the Mytton Beds include two outcrops of thick intrusive igneous rock, that on the east behaving as a sill, that on the west as a dyke, oblique to the bedding. At the northern end of the anticline the two outcrops of this rock come close together, the actual nose of the anticline being cut off and dropped by a fault trending west-north-west and east-south-east. On the west side the Mytton Beds dip west-north-west or north-west at 60° or more, and the intrusion on this side dies out south of the

Roman Gravels Mine, where the dip of the Mytton Beds is lessened, and the dyke-like intrusion is oblique to their bedding-planes. On the east side the inclination of the beds varies from 30° to 60°, and the intrusive sheet persists throughout.

The mines described are: Nick Knolls, Batholes, East Roman Gravels, Roman Gravels, Ladywell, Foxhole, Grit, White Grit, Shelve Pool, and South Roman Gravels. These all belong to the Shropshire Mines, Ltd., group, and most have been big producers in the past.

In the eastern area or Callow Hill-Bog district, the chief mines are the Snailbeach, Callow-Hill, Myttonsbeach, Perkins Beach, Burgam, Tankerville, Potter's Pit, Pennerley, Bog, Rock House, and Rhadley. Some of these belong to the Shropshire Mines, Ltd., group. The notable exception is Snailsbeach, a celebrated producer in old days, but now worked only for accumulated tailings and for barytes.

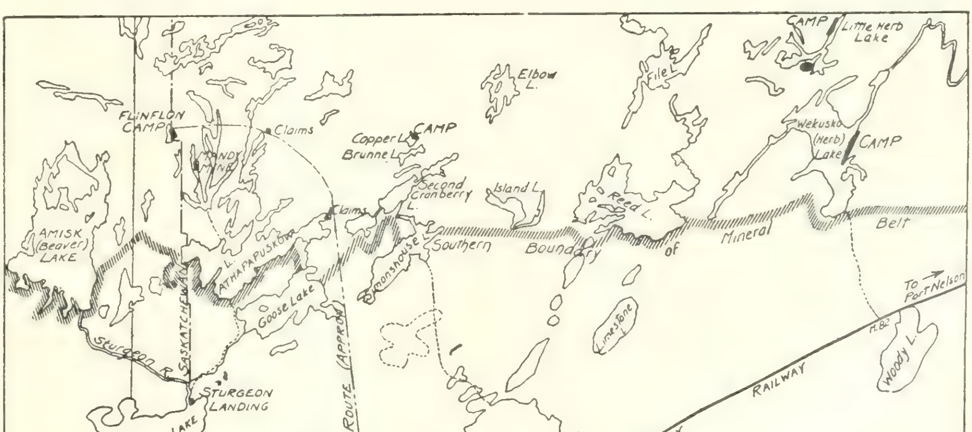
The central area, or Buxton Hill-Cefn Gwynlle district, is of less importance; and the mines not classified as belonging to the above-mentioned three districts are mostly on or over the borders in Montgomery, and have not been important producers.

Gold in Manitoba. — The interest taken at present in the gold prospects of Northern Manitoba makes the appearance of a paper by J. P. Gordon in the February *Bulletin* of the Canadian Institute of Mining and Metallurgy particularly welcome, for on this side of the Atlantic the perspective of these new discoveries is apt to be distorted. The subject has received attention in many previous issues of the MAGAZINE, but under present conditions no apology need be made for referring to the matter once again by quoting liberally from Mr. Gordon's paper. In previous issues this mineral district has been called "The Pas" district. It is convenient to divide the district into six camps, namely: Flin-Flon, Athapapuskow, Beaver Lake, Copper Lake, Herb Lake, and Elbow Lake; and to classify the ore deposits as: (1) Sulphides carrying commercial values in the base metals (gold as a by-product); (2) sulphides carrying commercial values in gold; (3) Quartz lode ores, in which the sulphide contents are less than 5% of the weight of the ore; (4) Granite shear zones: native gold occurring in crystalline quartz on the shear faces of the granite and to some extent in the sulphides contained in the granite.

(1) This class includes the Flin-Flon, Mandy, and Athapapuskow deposits. On the Flin-Flon sufficient work has been done by diamond-drilling, shaft-sinking, driving, and cross-cutting to block out 20,000,000 tons of copper ore, with an approximate assay value of $1·00 in gold per ton. It is generally understood that, when the market price of copper becomes normal once more, the Mining Corporation of Canada will develop this property on a scale commensurate with the size of the ore-body.

(2) On Brunne and Copper Lakes there is a large sulphide body running in a north-easterly and south-westerly direction. On the Deighton claim, at the north-east end of Copper Lake, this ore deposit is approximately 1,000 ft. wide. Gold values in lump samples have run as high as $2·80, and coarse gold has been found within a few hundred feet of the north and south sides of the heavy mineralization. There are probabilities here.

(3) This class embraces all the quartz lode



MAP OF NORTHERN MANITOBA MINING DISTRICT.

deposits. On Copper Lake the vein was explored by surface-work and diamond-drilling for a length of 1,400 ft. and to a depth of 200 ft. The pay ore was found to occur in shoots, the largest of which has the following dimensions: length axis, 213 ft.; thickness, 12 ft.; width, 36 ft. Assays of samples from the surface and from the drill core give an average of $7·80 in gold per ton, so that, reckoning 12 cu. ft. of rock to the ton, this shoot, as at present explored, should yield in the neighbourhood of $60,000 worth of gold; and if, as is quite possible, the shoot holds its dimensions and values to appreciably greater depths than the 200 ft. already drilled, its gold content would, of course, be several times the amount stated. Ore outside of the shoot has an assay value of $4·00. This is considered to be of too low grade to be mined economically under present conditions.

The discovery of gold in the Snow Lake field was made in August, 1921. Free gold was found in place on the Mint claim and on an outcrop 1,200 ft. to the south-east, on the Bear claim. The ore occurs in schistose zones of sedimentary gneiss. The schistosity was probably imposed upon the rock at the time of the intrusion of the granite which surrounds the district. The mineralization appears to be the same in all outcrops along the line of strike, and consists of arsenopyrite, tourmaline, and free gold. On the Mint, cross-trenching shows a 5 ft. quartz vein on the hanging-wall side, then 3 ft. of schist heavily impregnated with sulphides, followed by alternate quartz and schist bands to the end of the 35 ft. trench. A depression follows the strike at the end of the trenching and the overburden is heavy. On the Aurus claim there is an outcrop of quartz 30 ft. long by 4 ft. wide. Stripping on the Bear claim shows an extreme width of 17 ft. of quartz, and on the Camp Fire of 6 ft. Indications are in favour of depth, as all the contained minerals have been formed at a high temperature. A number of samples taken on the Mint claim ranged from $2·00 to $12·40 in gold per ton, and on the Bear from $2·00 to $16·80 per ton. This camp looks very promising.

A considerable amount of work has been done on a system of veins that parallel the west shore-line of the north arm of Little Herb Lake. Free gold occurs in several places, and on one claim a shaft has been sunk 20 ft. At the collar of the shaft the vein is about 8 in. wide and seemingly free from sulphides; at the bottom of the shaft the quartz has a width of 2 ft. and bands of sulphides parallel the strike of the vein for the full width of the shaft, 9 ft. Free gold in fair amount was found at this level. From collar to the bottom of the shaft, the rock will average $30 per ton for a width of 5 ft. Two feet of the wall-rock on the hanging-wall side seems to carry higher gold values than the vein proper.

The Rex property at Herb Lake is undoubtedly destined to be a producer when properly equipped with mining and milling machinery and sufficient capital to carry on underground work economically. The property has a vein exposure of some 2,000 ft. by 3 ft., and channel samples taken on the surface have yielded an average value of $17 in gold per ton. The shaft averaged $40 per ton to the 255 ft. level, and from the small amount of work done by sinking and driving, gold to the value of $33,800 was produced.

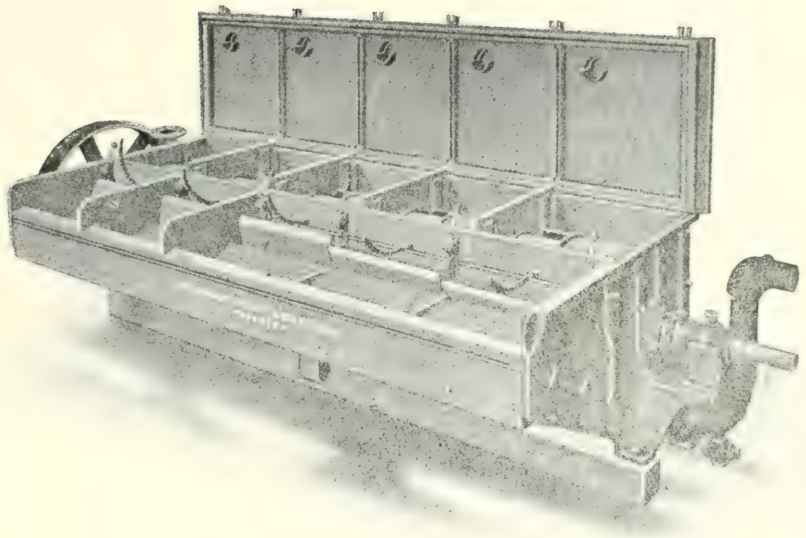
The Northern Manitoba property, to the south of the Rex, produced $2,323 in gold from a trial shipment of 57,000 lb. of gold-bearing quartz, or $81·53 per ton. To the north of the Rex, the Bingo has a shaft down 125 ft., and Professor DeLury has reported very favourably on this property's probabilities.

(4) Elbow Lake forms a basin set within a basin of greenstone, which is surrounded by granite walls except for an opening at the inlet and outlet of the lake, which are both at the south end of the lake and only separated by a narrow peninsula of greenstone, striking in a south-westerly direction for a considerable distance. The inlet flows north-east on the west side of the greenstone peninsula and the outlet in the opposite direction along the other wall or line of contact. The Murray claims are situated at the outlet of the lake about one mile south of the extreme end of the peninsula. With regard to their economic possibilities, Professor R. C. Wallace says: "The Murray and Contact claims are staked on a contact zone between granite and greenstone in which there is a variety of intermediate rock and irregular quartz lenses and sheets with very high values in gold. Both the quartz and the contact rock carry considerable pyrite. In view of the remarkable distribution of gold in the quartz there is the opportunity in this property, and on this contact generally, for prospecting an ore-body of large size, with sufficient values for large-scale operations." Hollinger interests have taken an option on this property, and its probabilities will be known before long.

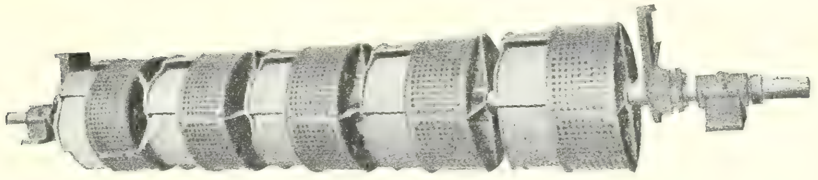
About six miles east of the Murray claims, and on the same contact, a large quartz vein, 20 ft. wide, has recently been discovered. Paralleling this vein are two others, one 2 ft. and the other 7 ft. in width. The earthy oxidation products on all three veins pan heavy gold, and free gold has been found in place. This find has considerable significance, as the fracture would offer a favourable place for the deposition of the gold values that the Murray property proves were existent at the time of mineralization.

The Akins Flotation Machine.—The *Mining and Scientific Press* for February 25 contains a description of a flotation machine designed by R. P. Akins, and made by the Colorado Iron Works Co., of Denver. Recognizing that aeration is one of the most important factors in flotation, the inventor considered it desirable that the regulation of the air should be independent of the amount of agitation. The method used in his machine consists in successively taking definite quantities of a froth-producing, mineral-containing liquid and air, and commingling them to thoroughly aerate the same, and thereafter releasing these below the surface of a body of similar liquid to effect the frothing. The machine is not dependent on any extraneous source for air-supply or emulsification, nor does it require a high speed of rotation to effect the commingling of the measured air and liquid; hence the wear is reduced to a minimum, as well as the power used. In addition, the amount of frothing in each cell is at all times under control of the operator. The method of air supply and its positive control does away with close attention, so that in a plant having a large number of machines, one operator can easily attend to many of them.

The tank is constructed of wood, with cast-iron ends. The cover of the tank is removable, to give access to the interior. Vertical partitions divide the tank into a number of cells, the only communication between them being through openings



THE FOUR-CELL AKINS FLOTATION MACHINE.



THE ROTOR AND DIFFUSION MEMBER.

at the bottom to permit the passage of pulp from one cell to the next. In front of, and integral with, each cell, is the usual spitzkasten, in which is placed at about the liquid level a screen slightly inclined from the horizontal, and used as a baffle to create a quiescent area for the froth ; and a booster board which is slightly above the level of the froth-overflow weir. This board is adjustable as to its inclination, and causes the froth to flow toward the weir without the use of sweeps.

Mounted on the cover above each cell and over the rotor, is a valve, conveniently placed for adjustment by the operator, by means of which admission of air to the cell is controlled and the amount of frothing and grade of concentrates produced is regulated. As the cells are practically airtight, by closing this valve on any cell the same can be used as an emulsifier when adding reagents in that cell, and no frothing action takes place in that cell so long as its valve remains closed.

The rotor or aeration member is similar in form to a multiple scoop tube-mill feeder ; that is, it comprises two discs with a series of partitions which form passages leading spirally from the periphery to the centre. The rotor is mounted on the horizontal shaft of the machine, and in operation is partly submerged in the pulp, the unsubmerged portion extending into the air-chamber of the cell. It is rotated in the direction which causes each spiral passage to take in air when above the liquid level, this air being trapped as the opening enters the pulp, and on reaching the lower part of its revolution it takes in a measured quantity of pulp. The air-chamber of the cell being practically airtight, the action of the rotor, if air were not admitted, would be to exhaust the chamber of its contained air. Indeed, with the air-valve closed there is a decided rise in the level of the pulp in the air-chamber, and the regulation of air really rests upon this difference of level ; when low, due to free admission of air, the measure taken in by each scoop is much larger than when a restricted admission of air causes the pulp to rise, thereby filling a larger portion of the spiral passages and leaving a correspondingly smaller space for the air. In the centre of one side of the rotor is an opening communicating with the interior of the diffusion member, and through this opening the measured volumes of pulp and air pass.

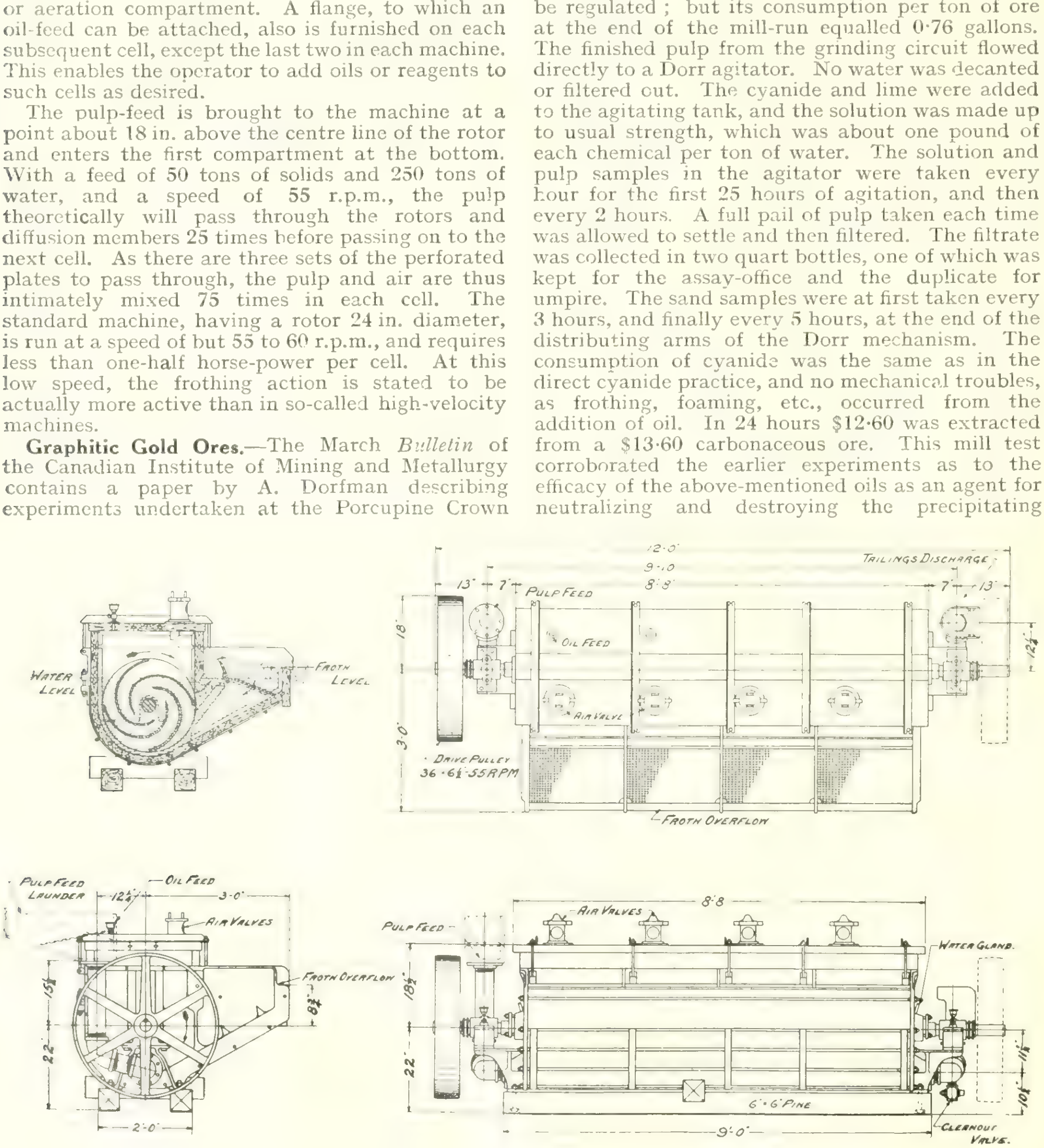
The diffusion member consists of a series of three concentric hollow cylinders perforated with square holes. It forms a prolongation of the rotor, and one end is closed by the end wall of the rotor (except for the central opening just mentioned), the other end being closed by a disc attached to the shaft. The pulp and air flow through the central opening in the rotor into the innermost of the perforated cylinders and pass successively through all three of them. The rotation of the diffusion member causes the air to be broken up into minute bubbles thoroughly commingled with the ore particles, so that through the outer cylinder there issues a thoroughly aerated mixture in an ideal condition for flotation.

There is a general flow of this aerated pulp below the front wall of the diffusion-chamber into the spitz. The froth formed rises mainly between the front wall of the diffusion-chamber and the booster-board, the purpose of this being to direct the flow of the froth toward the overflow weir. Any mineral particles not thus recovered upon their first passage through this circuit, pass back into the rotor, or into the next cell, depending upon the rate of feed of material into the machine.

An oil-feed cup is furnished on the first cell of each machine for feeding the oil into the differential or aeration compartment. A flange, to which an oil-feed can be attached, also is furnished on each subsequent cell, except the last two in each machine. This enables the operator to add oils or reagents to such cells as desired.

The pulp-feed is brought to the machine at a point about 18 in. above the centre line of the rotor and enters the first compartment at the bottom. With a feed of 50 tons of solids and 250 tons of water, and a speed of 55 r.p.m., the pulp theoretically will pass through the rotors and diffusion members 25 times before passing on to the next cell. As there are three sets of the perforated plates to pass through, the pulp and air are thus intimately mixed 75 times in each cell. The standard machine, having a rotor 24 in. diameter, is run at a speed of but 55 to 60 r.p.m., and requires less than one-half horse-power per cell. At this low speed, the frothing action is stated to be actually more active than in so-called high-velocity machines.

Graphitic Gold Ores.—The March *Bulletin* of the Canadian Institute of Mining and Metallurgy contains a paper by A. Dorfman describing experiments undertaken at the Porcupine Crown mill with a view to finding a method of counteracting the precipitating effect of graphite contained in the schist. The result of these experiments was to ascertain that by adding oil to the ore the pulp could be treated direct in the cyanide plant with a satisfactory recovery. The author does not describe the process as eventually adopted, reserving this for a future paper, but he gives a brief description of the first experimental mill-run using oil. The crushing and grinding of the ore was in water, and a mixture of crude, fuel, and gas-oil was added to the ball-mill and tube-mill scoops. The oil was added by a very small but continuous flow from an inverted 5-gallon can, fitted with a special cock. The amount of oil added could not be regulated ; but its consumption per ton of ore at the end of the mill-run equalled 0·76 gallons. The finished pulp from the grinding circuit flowed directly to a Dorr agitator. No water was decanted or filtered out. The cyanide and lime were added to the agitating tank, and the solution was made up to usual strength, which was about one pound of each chemical per ton of water. The solution and pulp samples in the agitator were taken every hour for the first 25 hours of agitation, and then every 2 hours. A full pail of pulp taken each time was allowed to settle and then filtered. The filtrate was collected in two quart bottles, one of which was kept for the assay-office and the duplicate for umpire. The sand samples were at first taken every 3 hours, and finally every 5 hours, at the end of the distributing arms of the Dorr mechanism. The consumption of cyanide was the same as in the direct cyanide practice, and no mechanical troubles, as frothing, foaming, etc., occurred from the addition of oil. In 24 hours $12·60 was extracted from a $13·60 carbonaceous ore. This mill test corroborated the earlier experiments as to the efficacy of the above-mentioned oils as an agent for neutralizing and destroying the precipitating



Working Drawing of the Four-Cell Akins Flotation Machine.

properties of a carbonaceous schist on a gold cyanide solution.

[Note is made elsewhere in this issue of another process invented by the metallurgist of the Tonopah-Belmont Development Co., for securing the non-interference of carbon with the cyanide extraction of gold.—EDITOR.]

Gold Assay.—At the March meeting of the Institute of Metals, Arthur Westwood, of the Assay Office, Birmingham, described a modified method of assaying gold bullion. In the gold alloys used for coinage, jewelry, and plate, there may be present silver, copper, zinc, tin, and iron. The present standard method of assay is of ancient origin and consists of cupellation, inquartation, and parting. In Mr. Westwood's method, cupellation—the principal object of which is the elimination of oxidizable or "base" metals—is omitted, and, for inquartation, copper is preferred to silver. The loss of gold by absorption in the cupel when high-grade alloys are assayed amounts to 0·400 per 1,000, and all other losses to only 0·006 per 1,000. The cupellation less is much greater with low-grade bullion. By Mr. Westwood's method there is no appreciable loss of gold, and the surcharge is always plus with any grade of bullion.

By the new method care is taken to prevent as much as possible the elimination, before parting, of the constituents other than gold contained in the samples. A weight of 5 grains is a convenient quantity to take. The weighed assays are each put into a separate cup of clay, without lead or any other addition than a weight of copper (or copper containing a deoxidizer, say, 0·5% of zinc), which with the alloy present in the assay sample will amount to, say, 2 to 2¼ times the weight of the gold present. These assays are then melted and balled up in a heated silica tube under a steady slow current of steam. Five minutes at a temperature a little above the melting point of copper—which point is determined by a fragment of copper—is usually sufficient, but when a large percentage of zinc is present, ten minutes should be given. An inert gas, such as nitrogen or carbon dioxide, may be used, but steam is preferable, as it is always available and is of assistance in the oxidation and removal of minute traces of certain metallic impurities which may be present in the alloy.

With an alloy of gold and silver or copper, or a triple alloy of these metals, a malleable, clean, bright bead or button is obtained. The same is also true when zinc is present, the latter metal, however, being oxidized and volatilized. The loss in weight of the bead, if the quantity of zinc is considerable, has to be made up with an equal quantity of parting copper. This loss gives fairly correctly the amount of zinc in the sample. Alloys for plate and jewelry of 9 carat fineness are now often met with containing as much as 7% zinc. The results obtained from such alloys by cupellation are most unreliable, but by the method suggested they are quite satisfactory.

When metals other than these are present in very minute quantities their presence is indicated, and may be recognized, by the appearance of the bead. For example, with iron the bead is partly or completely scaled with black magnetic oxide. This may be chilled off without loss of gold, and the bead is then quite free from iron. Other metals give a dull, matted, and tinted appearance to the bead. The following metals, if present in quantity less then 0·1%, have not been found detrimental to the process: nickel, cobalt, zinc, cadmium, lead, iron, tin, antimony, and aluminium.

The inquarted bead is hammered and may be rolled out into a fillet without annealing. If annealing is desired (though it is found to be unnecessary) this may be done under steam or coal-gas. The fillet is not coiled in a spiral, but is merely doubled on itself, and is then parted and subsequently annealed in air in the usual manner.

Should antimony, aluminium, or tin be present in the original alloy, they will occasion a surcharge as is the case with cupellation. If as little as 0·2 per 1,000 of either is contained in the parted and annealed fillet, their presence is perceptible to the naked eye, for the gold is without lustre and tarnished. Tin in this quantity gives a very marked reddish tinge to the fillet. With 0·5 per 1,000 the fillet is too brittle to bear handling.

A gas muffle furnace, in which the clay muffle is replaced by five or six silica tubes, 1⅛ in. bore and 3 ft. long, is a suitable arrangement when a large number of samples have to be put through quickly. Half of the length of each tube projects in front of the furnace, and into the unheated half the molten assays are drawn to set and cool. Each tube is connected at the back of the furnace with a steam generator, which is heated by the furnace itself. In front the tubes are open. The cups used are deep and steep-sided depressions, formed in a clay stick 9 in. long, and of semicircular section, so as to slide within the tubes. There are ten such cups in each stick. A little powdered graphite is mixed with the clay. These clay sticks are moulded by hand, and may be used over and over again, each stick costing in material a fraction of a penny. Each time they are used the cups are smoothed inside with emery-paper. When past use the material is pounded and used over again. The silica tubes are found to last a long time, eighteen months and more, though fired for six or seven hours a day. When the heated halves show signs of decay, the tubes are reversed, so doubling their life.

Electric Smelting of Copper Ores. — In the *Engineering and Mining Journal* for March 4, C. S. Witherell and H. E. Skougor describe the Westly electric furnace designed at Sulitelma, Norway, for smelting copper ore and concentrate. This furnace was used during the war when fuel was difficult to obtain. It consists of a boiler-iron shell, lined with standard refractories, an open arched roof, with regular electrode openings, and holes along the skewbacks for charging. The electrodes are fed vertically through the top. At first, single-phase alternating current and two electrodes were used in the furnace. Later, three-phase alternating current, with three, and up to six, electrodes, according to the size of the furnace, were also used. Preferably, the electrodes are placed in a straight line, although the delta arrangement has been used. The design and construction do not differ much from the Heroult smelting furnace. A transverse section is similar to that of a modern smelting reverberatory. The ore, charged through roof openings along the skewbacks, banks against the sides and forms, as it melts, a molten pool in the centre composed of slag and settling matte. A sump is incorporated in the hearth of the furnace, preferably at one end, for the purpose of diverting the settled matte away from the electrode tips and also to provide a larger bulk for tapping. The electrode tips dip into the slag layer, but are kept a considerable distance above the matte layer ; hence the heating is done entirely by the current passing through the slag between the electrode tips, the matte layer carrying practically no current. This takes advantage of the fact that all mineral substances that are electric insulators when cold become high-resistance conductors when above a red heat. There is no arc action when the furnace is running normally. The experimental work covered several sizes of furnaces, from 200 kw. to 900 kw., and furnaces of various shapes. Because of the success of the initiatory tests, the company undertook to build a 3,000-kw. furnace, which was almost completed before plant operation was stopped at the end of the war.

The principal ore treated consisted of mixed sulphides, namely, copper pyrites, iron pyrites, and pyrrhotite, in a gangue of gabbro and phyllitic slate. The mined ore was partly concentrated, which gave a product for smelting analysing on the average 6% Cu, 28 to 30% S, and 28% SiO_2. Usually, part of this concentrate was roasted and mixed with the raw portion before charging into the electric furnace, thereby producing 30 to 40% copper matte direct. The slag usually ran 0·3 to 0·4% Cu. No fuel was added with the charge nor used extraneously. The slag loss was cut from 10 to 20% in previous methods to 5 to 6% in the electric method. Also, the slag could be varied considerably in composition ; successful slags analysing up to 62% SiO_2 were run.

Electric-power consumption in regular operation was less than 700 kw.-hr. per metric ton of ore smelted. The furnace voltage varied from 112 to 230 volts, depending on the space between electrodes and resistivity of the molten slag ; the more siliceous the slag, the higher the resistivity. The 3,000-kw. furnace mentioned above was expected to smelt 100 tons of charge per day. The electric current used was three-phase, fifty-cycle. The consumption of electrodes for regular smelting amounted to 3 to 4 kg. of carbon electrode material per metric ton of ore smelted.

A Possible Origin of Petroleum.—A paper was presented at the February meeting of the American Institute of Mining and Metallurgical Engineers by Colin C. Rae, in which he discussed a possible origin of petroleum. According to the author, the absence of paraffin hydrocarbons in the soil, though they are concentrated in extensive deposits in some localities, the common distribution of plant remains through many formations that are not productive for oil, and many other factors, seem to indicate the existence of an intermediate organic compound between the complex plant compounds and the paraffin hydrocarbons ; and much evidence points to the humus acids or associated organic compounds, which are probably collected by surface waters and concentrated in certain areas by means of precipitation by electrolytes, which would be contained in sea water or possibly in various island seas or lakes.

There are many present-day evidences of the association of petroleum with humus acids. Many of the rivers carry much humus acid in solution, and some tropical rivers carry in the aggregate millions of tons of humus each year. The analyses of various river waters show a close relationship between the amount of organic matter and the amount of free uncombined silica. By chemically equating the positive ions to the negative ions in the various analyses of river waters, there is apparently an excess of free silica, most probably in a colloidal state, varying from a fraction of 1%, in rivers with little organic content, to 44% in tropical rivers, such as the Uruguay. The relation between the silica and humus is not clearly understood, and prominent chemists have given conflicting views concerning the physical and chemical relationship.

The combined silica is chiefly in the form of sodium metasilicate, which has been shown, by Kohlrausch and others, to be hydrolysed in solution into colloidal silica and sodium hydroxide. Uncombined silica must be present as colloidal silica since silicic acid hydrolyses, forming the colloidal solution.

Another factor to be considered is the possible precipitation of organic compounds by sea or inland lake waters. Binney, Haseman, and others have called attention to the association of formation of petroleum or asphalt with humus conditions in the presence of sea water. Chemically, the coagulation of colloids is effected by electrolytes such as $Al_2(SO_4)_3$, $Fe_2(SO_4)_3$, $FeCl_3$, and other salts, when present in sufficient quantity. When sufficient electrolyte is added to the colloidal suspension, the colloidal particles attract the oppositely charged ions, and the difference in potential between the colloid particles and water decreases, increasing the surface tension. As a result, the colloid particles are drawn nearer together and are precipitated. Hence, the coagulation of organic matter, colloidal silica, and sulphur can be effected by sea water, due to the presence of the needed electrolytes.

Experiments by prominent chemists have proved that the humus-acid groups, whose exact chemical composition is not well understood, can become colloids, and as colloids are easily precipitated by sodium chloride, calcium sulphate, and other salts. This fact probably explains the action of sea water in removing organic impurities from the river waters.

The gradual transformation of the organic hydrocarbons, precipitated by the electrolytes of the sea water, into the petroleum hydrocarbons could probably take place under several sets of conditions and would vary according to alkalinity, salts, and the presence of catalytic agents in associated formations, together with conditions of pressure and temperature. The evidence of action of sea water on waters of peat bogs seems to indicate that a slight amount of petroleum can be formed under proper conditions even where only normal conditions of pressure and temperature are present.

In the oil-shale beds of the western states, intermediate organic compounds between the humus and paraffin hydrocarbons are apparently present, which require heat to change into petroleum. The character of the intermediate compound has been the subject of much discussion and comment, the prevailing idea being that the organic matter was chiefly carbonaceous and plant remains. However, microscopic studies of the shales have shown that while pieces of plants, pollen grains, seeds, and spores are numerous in the shale with low oil content, the rich shales have virtually no plant or organic remains, but apparently have some intermediate organic compound between the organic material and oil which may be changed to petroleum on application of heat and pressure.

Webster's Copper Process. — The *Engineering and Mining Journal* for March 4 and 18 makes brief reference to the Webster process for treatin copper ores. This process has been the subject o patent litigation, but the way for its application is now apparently clear. The patent rights have been acquired by the Merrill Company, of San Francisco. The process has for its purpose the recovery of the copper in oxidized copper minerals, either alone or in the presence of sulphide copper minerals. A dilute solution of sulphuric acid is first used to dissolve the copper present in oxidized form in a finely ground pulp. Finely divided iron is then added, and the copper is precipitated in the pulp. The metallic copper and the sulphides are then recovered by subjecting the pulp to flotation. The steps in themselves are not novel, but the combining of them and the precipitation of the copper in the pulp are original, and lead to important results in the treatment of a type of copper ore which has given considerable trouble to metallurgists. The inventor worked on leaching oxidized copper ores at Butte, Montana, and, owing to difficulties in the separation of the acid copper solution from the pulp, evolved the idea of precipitating the dissolved copper in the pulp as metallic copper, when the separation would be easily accomplished. Later, some experimental work was done at the East Butte Copper Mining Co.'s plant, with encouraging results.

SHORT NOTICES

Handling Ore at Butte.—A paper was presented at the February meeting of the American Institute of Mining and Metallurgical Engineers by H. R. Tunnell, on the means employed for moving ore from the stopes to the surface.

Wire Ropes in Mining.—At the February meeting of the American Institute of Mining and Metallurgical Engineers a number of papers were presented dealing with practice in connexion with the use of wire ropes in mines.

Sampling Ore-Bodies.—At the February meeting of the American Institute of Mining and Metallurgical Engineers, a number of papers on sampling practice in mines were presented.

Valuation of Ores.—At the March meeting of the Institution of Mining and Metallurgy, L. C. Stuckey presented a paper on the valuation of ores, concentrates, and smelter products.

Mine Survey.—At the March meeting of the Institution of Mining and Metallurgy, L. H. Cooke presented a paper entitled "Methods of Measuring Horizontal Angles involving Steep or Precipitous Sighting."

Boring through Earth. — The *Engineer* for March 10 gives further examples, with illustrations, of the Mangnall-Irving system of boring horizontal holes in the earth by hydraulic thrust pressure. This process has been noted in the MAGAZINE on several recent occasions.

Steam-Shovel Practice.—A paper was read at the February meeting of the American Institute of Mining and Metallurgical Engineers by H. M. Ziesemer and G. Mieyr on steam-shovel practice at the properties of the Phelps Dodge Corporation.

Copper Production Costs.—In the *Engineering and Mining Journal* for March 18, H. A. C. Jenison writes on the fluctuations in the costs of copper mining from 1909 to 1920.

Mining Methods at Porcupine. — The March *Bulletin* of the Canadian Institute of Mining and Metallurgy contains papers on mining and metallurgy at the Hollinger and McIntyre gold mines, Porcupine, Ontario.

Coal Cleaners. — *Engineering* of March 24 describes an automatic spiral coal separator made in the United States. Advantage is taken of the different frictional resistances of coal and shale, and the machine works on the same principle as Stanley Nettleton's machine described in the MAGAZINE for October, 1921.

Brown Coal.—At a meeting of the Royal Society of Arts held on February 24, Dr. W. A. Bone read a paper on lignites and brown coals, dealing with the aspect of their importance to the British Empire.

Metallurgical Calculations. — The December *Journal* of the Chemical, Metallurgical, and Mining Society of South Africa contains a paper by H. A. White on the correlation of metallurgical statistics.

Cyaniding Flotation Concentrates. — In the *Mining and Scientific Press* for February 11, Paul T. Bruhl describes tests of cyaniding flotation concentrates at the Sabana Grande Honduras Mining Co.'s mines.

Roasting Zinc Ores.—In the *Engineering and Mining Journal* for February 18, Thomas French discusses several points in connexion with the roasting of zinc ores before electrolytic treatment.

Alabama Graphite.—In the *Engineering and Mining Journal* for March 11, G. H. Clark gives an account of the present position of the Alabama graphite industry.

Copper in Granada, Spain.—The *Mining and Scientific Press* for March 4 publishes a paper by Courtenay De Kalb on copper deposits in the Sierra Nevada, Granada, South Spain.

South African Coalfields.—At the January meeting of the Geological Society of South Africa, Dr E. T. Mellor read a paper entitled: "Recent Additions to our Knowledge of the South African Coalfields." Our South African correspondent referred to this paper in the last issue.

Geology of New Zealand.—The *Journal of Geology* for February contains a paper entitled "An Outline of the Geology of New Zealand", by W. N. Benson, of Otago University. This paper is based on the author's address on the subject delivered before the Australasian Association for the Advancement of Science last year.

RECENT PATENTS PUBLISHED

☞ *A copy of the specification of any of the patents mentioned in this column can be obtained by sending 1s. to the Patent Office, Southampton Buildings, Chancery Lane, London, W.C. 2, with a note of the number and year of the patent.*

28,436 of 1920 (175,333). A. C. VIVIAN, Clacton-on-Sea. In concentration processes, such as flotation or electrostatic separation, mixing the ore with a chemical solution which will deposit metal upon the valuable constituents and thus render them separable.

29,185 of 1920 (174,995). INTERNATIONAL PRECIPITATION Co., Los Angeles. Method of removing and collecting the material deposited on the electrodes in the electrostatic separation process.

29,235 of 1920 (175,348). G. A. BLANC and F. JOURDAN, Rome. In extracting potash from rocks, heating these rocks to high temperatures in an atmosphere of hydrochloric acid, the effect of the heat being to decompose the chlorides of iron, aluminium, calcium, and magnesium formed by the action of the acid, while the potassium and sodium chlorides formed are not attacked but can be leached out of the insoluble residue.

30,960 of 1920 (174,739). S. NETTLETON, London. Separating minerals from each other by taking advantage of their varying frictional resistances when passing over metal surfaces. This method was described in the MAGAZINE for September, 1921.

31,963 of 1920 (175,384). R. J. LEMMON, H. L. SULMAN, and MINERALS SEPARATION, LTD., London. Method of applying the froth-flotation principle to the extraction of gold from Rand and similar ores.

32,060 of 1920 (154,534). E. C. HANSON and W. L. V. CARLSON, Washington, U.S.A. Method of locating ore-bodies, which consists of subjecting the ore-bodies to an audio frequency alternating current through the intervention of a balanced circuit and determining the mass of the ore-body by the adjustment necessary to restore the circuit to balanced condition.

32,614 of 1920 (155,816). J. H. HERMAN, Melbourne. Improvements in swivel sockets employed to connect wire cables to the stems or jars connected to boring-bits used in boring deep wells by the percussion system.

32,615 of 1920 (155,817). J. H. HERMAN, Melbourne. Improved under-reaming percussion bit for boring a hole of enlarged diameter.

33,461 of 1920 (175,116). A. EHRAT, Zurich. Winning petroleum or gas by sinking shafts, then driving levels around and below the oil pools, and drilling bore-holes from these levels in an upward direction.

35,326 of 1920 (155,299). W. NORTH and H. LOOSLI, Hanover. Electric furnace and method for producing metallic zirconium.

1,882 of 1921 (174,522). CLEVELAND ROCK DRILL, Co., Cleveland, Ohio. Improved feed for hand-fed hammer-drill.

2,425 of 1921 (174,282). R. BINNIE, Bolivar, Pennsylvania. Improvements in rotary reciprocating drills.

3,251 of 1921 (158,562). T. GOLDSCHMIDT, Essen. Bearing metal containing 75 to 85% lead, up to 10% tin, with some antimony, and about ½% of phosphorus. The last named is introduced by adding phosphor copper or similar alloy. These alloys are hard and do not scale, and form substitutes for the bearing metals high in tin.

4,629 of 1921 (175,188). INGERSOLL-RAND CO., New York. Throttle valve for rock-drills.

5,889 of 1921 (161,159). SOCIETE DE L'EVAPORATION PROCEDES PRACHE AND BOUILLON, Paris. Rotating cylindrical apparatus for leaching nitrate of soda from nitrate deposits.

5,952 of 1921 (175,899). A. MCCRACKEN, London. Expansible rock-drill for widening the bottom of holes so that they may hold larger amounts of explosive.

6,449 of 1921 (175,542). G. H. T. RAYNER and P. RAYNER, Sheffield. Improved worm-gear for coal-cutting or channelling machines.

10,606 of 1921 (175,918). A. RADE, Johannesburg. Improved method of lighting the fuses of blasting charges.

10,634 of 1921 (173,999). R. EMMOTT and T. MERCER, Burnley. Pulverizing machines of the rotating hammer type.

15,813 of 1921 (174,306). D. TYRER, Stockton-on-Tees. Manufacture of red iron-oxide pigment from ferrous chloride contained in galvanizer's waste pickle by treating with barium carbonate and afterwards calcining the precipitate, barium chloride being a by-product.

17,130 of 1921 (169,144). ISABELLENHUETTE, Dillenburg, Germany. A hard silver alloy containing aluminium and manganese, with portions also of copper, silicon, and other metals.

NEW BOOKS, PAMPHLETS, Etc.

☞ Copies of the books, etc., mentioned below can be obtained through the Technical Bookshop of *The Mining Magazine*, 724, Salisbury House, London Wall, E.C. 2.

Petroleum Laws of All America. By J. W. THOMPSON. Paper covers, octavo, 650 pages. Bulletin 206 of the United States Bureau of Mines.

Quin's Metal Handbook and Statistics. By L. H. QUIN. Price 5s. net. London: The Metal Information Bureau, Ltd. This is the ninth yearly issue of a statistical publication of great value in the metal trades.

A Manual of Flotation Processes. By A. F. TAGGART, Professor of Ore Dressing in Columbia University. Cloth, octavo, 182 pages, illustrated. Price 16s. 6d. net. New York: John Wiley & Sons; London: Chapman & Hall, Ltd.

Manufacture of Sulphuric Acid by Contact Processes; being No. 5 of the Technical Records of Explosives Supply, 1915-18. Price 25s. net. London: The Department of Scientific and Industrial Research. This volume gives particulars of the Mannheim and Grillo processes.

Mathiesons' Mid-Monthly Supplementary List. Monthly; 42s. per year. London: Frederic C. Mathieson & Sons, 16, Copthall Avenue, E.C. 2. This monthly publication contains quotations of securities unquoted on the Stock Exchange but in which dealings are marked. It is important to record that the publication now gives quotations of the shares of mining companies.

Lead during the War Period. Paper covers, octavo, 98 pages. Price 3s. net. Published by the Imperial Mineral Resources Bureau. This is another of the useful statistical monographs on metal and mineral production now in course of issue. It gives details of the world's production of lead during the years 1913 to 1919, with particulars of the occurrence of lead minerals, and production of ores, concentrates, and metal in each individual country.

Elements of Astronomy for Surveyors. By R. W. CHAPMAN. Second Edition. Cloth, octavo, 260 pages, illustrated. Price 6s. net. London: Charles Griffin & Co., Ltd. We referred in the issue of August, 1919, to the first edition and published an appreciative detailed review. The second edition contains a few brief corrections and additions. It is gratifying to find that the book has been well received in British and American technical centres.

Petroleum Refining. By ANDREW CAMPBELL. Second Edition. Cloth, octavo, 300 pages, illustrated. Price 25s. net. London: Charles Griffin & Co., Ltd. The first edition of this important work was reviewed in our issue of November, 1919. In the new edition a few corrections of minor importance are made.

Compressed Air in Mining. By DAVID PENMAN. Second Edition. Cloth, octavo, 260 pages, illustrated. Price 7s. 6d. net. London: Charles Griffin & Co., Ltd. This is a little book which has proved very helpful both to students and to workers in the mines. The author has won for himself a name for clear exposition and also as an authority on ventilation and the use of compressed air. His articles on air-compressors, rock-drills, and ventilation that have appeared in the MAGAZINE have been greatly appreciated by those desirous of having comprehensive but brief reviews of present practice. The new edition of the book now under notice contains much additional information relating to compressors and rock-drills, and the work is generally brought up to date. We understand that the publishers will shortly be publishing another book by Mr. Penman on the problems of ventilation.

COMPANY REPORTS

Hollinger Consolidated Gold Mines.—This company, the offices of which are at Toronto, operates a gold mine at Porcupine, Ontario. As has often been mentioned in the MAGAZINE, this property is by far the biggest gold mine in Canada, and is one of the great gold mines of the world. The report for 1921 shows that 1,072,493 tons of ore was milled, yielding gold worth $10,367,901, the extraction being $9·67 per ton. These figures compare with 650,205 tons, $6,219,664, and $9·67 the year before. The working cost was $5,222,855, taxes $429,889, and allowance for depreciation $627,488. The net profit was $4,026,927, and the dividends absorbed $3,198,000. The ore reserve is estimated at 3,402,609 tons, containing gold worth $36,644,154, figures very much the same as a year ago. As regards development the policy is to keep the reserves three or four years ahead of the mill. During 1921 the daily tonnage milled was nearly 3,000, and the rate of output is now at about 4,000, the maximum capacity of the plant. As mentioned last month it is planned to increase the scale of operations to 7,000 tons per day ; this expansion depends on the power-supply, negotiations for which are proceeding.

Kamunting Tin Dredging. — This company belongs to the Bright and Galbraith group, and has operated a tin dredge at Kamunting in the Larut district of Perak, Federated Malay States, since 1915. The report for the year ended June 30, 1921, shows that 963,500 cu. yd. of ground was treated, for an extraction of 429¾ tons of tin concentrate, equal to just under 1 lb. per yard. This was sold for £50,803, being on an average £118 per ton, or 12·65d. per yard. After allowing £4,926 for depreciation and £6,781 for amortization of capital, the net profit was £10,380. Income tax absorbed £7,352 and corporation tax £684 ; on the other hand £3,412 was recovered on account of excess profits duty, and a further amount, estimated at £9,000, will be recoverable. The total area of the company s property is 1,468 acres, of which 145 acres has been exhausted, 15 acres being worked during the past year. As already mentioned in the MAGAZINE, the company is about to acquire 141 acres from the Ipoh Tin Dredging Company, together with the dredge ordered by that company. The purchase price of the property and dredge is £53,000, payable as to £31,000 in cash, £21,000 in shares, and £1,000 in cash or shares. In order to provide funds, no dividend is being paid on last year's operations.

Bullfinch Proprietary.—This company was originally formed in 1910 to acquire gold claims north of Southern Cross, West Australia, and it was reconstructed in 1919. Small profits were made from 1913 to 1916. At the beginning of 1921, Bewick, Moreing & Co., were made general managers. In March of that year milling ceased and in August development was suspended. At the present time the water is rising, but will be kept at the 410 ft. level. The future policy is uncertain. The poor results of development and the high cost of supplies and labour make the outlook gloomy. The report now issued covers the year ended September 30, 1921. During the six months the mill was in operation, 27,430 tons of ore was treated for a yield of 6,046 oz., selling for £35,666, of which £9,871 represented premium. The accounts for the year showed an adverse balance of £8,843. Efforts to let the mine on tribute were unsuccessful. At the cessation of milling the ore reserve was exhausted. During the succeeding four months a run of ore was developed on the 410 ft. level for 113 ft., averaging 8·7 dwt. over 70 in., but all other development gave unfavourable results.

British Aluminium.—This company was formed in 1894 for the purpose of producing aluminium in Scotland by the hydro-electric method. It controls bauxite deposits in the south of France, has factories for producing alumina therefrom in Antrim and Fife, has smelting works at Kinlochleven in Argyll, Foyers in Inverness, and in Norway, and rolling mills in Stafford and Lancashire. The report for 1921 shows a profit of £221,506, out of which £158,223 is devoted to payment of taxation, debenture interest, and allowance for depreciation. Preference dividend at 6% and ordinary dividend at 5% absorb £68,025. The company does not give any details of the output of aluminium. Considerable extensions started in 1920 were completed during the year at the alumina works and rolling mills. The drop in demand which started in the latter half of 1920 continued throughout 1921, and two of the aluminium works and one of the alumina factories were shut down for a considerable part of the year. There have been signs of improvement since the close of the year, but some time must elapse before conditions in the trade become normal. The Bill, known as the Lochaber Water Power Bill, to enable the company to expand its operations at Kinlochleven received Royal Assent in July, 1921, but the company will not proceed with this scheme until the industry shows definite signs of improvement.

Mysore Gold.—This company belongs to the John Taylor & Sons group of gold mines in the Kolar district, Mysore State, South India, and has been a large and steady producer since 1884. Rather over two years ago additional capital was raised for the purpose of pressing development in depth, which had lagged behind during the war years. In this way it was possible to prevent a break in the long continuity of dividends. The report for 1921 shows that the tonnage of ore treated continues to decrease, being 202,289 tons as compared with 233,503 tons in 1920, 270,425 tons in 1919, and 293,186 tons in 1918. The yield of gold by amalgamation was 84,703 oz., and the cyanide treatment of 524,229 tons of sand and slime, current and accumulated, gave 45,231 oz., making a total production of 130,024 oz., or 24,734 oz. less than in 1920. The sale of the gold realized £687,207, and the profit was £207,799. The shareholders received £152,500, the rate being 25% on the capital. This rate was the same as that for 1920, and compared with 20% for 1919, but it looks small by the long series of dividends over 100% from 1896 to 1916. The reserve continues to decline, though slowly, standing now at 837,700 tons, as compared with 841,000 tons a year ago, but no assay-value is given. As regards development no less than 18,428 ft. was done during the year. It is disappointing to learn that the results at the bottom of Ribblesdale's section have been poor, for a year and two years ago hope was confidently expressed that ore of quality and quantity would be found there. Encouraging results, however, have been obtained on the eastern part of the lode in this section at and above the 57th level; and also in McTaggart's section on the main lode at the 46th level, where it is believed that the opening up of another shoot is in progress.

Globe and Phœnix Gold.—This company was formed in 1895 to work gold mines in the Sebakwe district of Rhodesia, and for many years much rich ore was extracted and large dividends were paid. Two or three years ago developments in depth began to give poor results. The report for 1921 does not give details of tonnage, but by reference to the monthly statistics given in the MAGAZINE it would appear that 66,787 tons of ore was treated and 65,910 oz. of gold extracted. The accounts show £289,437 as the par value of the gold, in addition to which £77,249 was received as premium. The profit was £182,143, out of which £90,620 was paid as income tax and corporation profits tax, while £80,000 was distributed as dividend, being at the rate of 40%. Development work has been actively conducted throughout the year, and ore of fair quality was disclosed, particularly on the foot-wall leader. The limits of this foot-wall shoot have now been determined, and work is being continued with a hope of finding further ore. The reserve on December 31, 1921, was estimated at 110,000 tons, averaging 25 dwt. per ton, as compared with 93,852 tons, averaging 31 dwt. per ton the year before.

Modderfontein B Gold Mines.—This company belongs to the Central Mining-Rand Mines group, and has worked gold mines in the Far East Rand since 1908. The report for the year 1921 shows that 769,328 tons of ore was raised, and after sorting 687,500 tons, averaging 10·87 dwt. per ton, was sent to the mill. The yield of gold by amalgamation was 206,449 oz., and by cyanide 155,417 oz., making a total of 361,866 oz. The sale of this gold realized £1,906,856, of which £384,697 accrued from premium. The working cost was £894,127, leaving a working profit of £1,012,729, out of which £665,000 was distributed as dividend, being at the rate of 95%. As compared with the previous year, the tonnage milled was 59,800 higher, the yield of gold 49,649 oz. greater, and the profit £94,306 greater. The yield per ton at par was 44s. 3d. as compared with 41s. 9d., the premium per ton 11s. 3d. against 13s. 7d., the working cost per ton 26s. against 26s. 1d., and the total profit per ton 29s. 6d. against 29s. 3d. The greater yield per ton was due to the fact that the ore mined was of greater assay-value than was estimated in the calculation of reserve. The development disclosed 683,840 tons averaging 9 dwt. per ton. Some blocks of low-grade ore have been eliminated from the reserve, which now stands at 2,773,300 tons averaging 9·6 dwt. as compared with 3,006,600 tons, averaging 8·6 dwt. the year before. The south-eastern shaft came into operation during the latter half of the year, and the south-western shaft was completed.

Durban Roodepoort Deep. — This company belongs to the Central Mining-Rand Mines group, and has worked a gold mine in the middle west Rand since 1895. Dividends have never been large. The costs are high, and of recent years the gold premium alone has made it possible to continue operations. Three years ago money was advanced by the parent company for the purpose of sinking a new shaft so as to facilitate the working of the deepest ground, but owing to unfavourable financial conditions, sinking was suspended in 1920. The report for 1921 shows that 352,879 tons of ore was raised, and that, after sorting, 318,550 tons, averaging 7·1 dwt. per ton was sent to the mill. The yield of gold by amalgamation was 71,284 oz., and by cyanide 36,710 oz., making a total of 107,994 oz. The par value of this gold was £453,486, in addition to which the premium brought an income of £114,171, making the total receipts £567,657. The working cost was £531,166, leaving a working profit of £36,490. The yield per ton at par was 28s. 6d., and the premium per ton 7s. 2d., making a total of 35s. 9d. The working cost per ton was 33s. 5d. Development about kept pace with extraction, and the ore proved was of about the same average as the reserves. Most of the work was done between the 15th and 16th levels. The reserves stand at 1,092,400 tons, averaging 6·5 dwt. per ton, divided about equally between the Main Reef and the South Reef

Robinson Gold.—This company owns what used to be in earlier days the great gold mine of the Rand. The first owner was J. B. Robinson, but the control was afterwards secured by the Ecksteins and the company now belongs to the Central Mining-Rand Mines group. During the last few years the yield of gold has been much smaller, owing to the exhaustion of the Main Reef Leader, and most of the ore has come from the lower-grade Main Reef. The report for 1921 shows that conditions of cost and premium make it impossible to continue mining the Main Reef, and arrangements were in hand before the strike for reducing the monthly tonnage from 40,000 to 12,000. There is, however, a very small amount of better-quality ore left, and that is mostly in pillars. During 1921 the amount of ore raised and treated was 460,300 tons, averaging 4·3 dwt. per ton. The yield of gold by amalgamation was 48,684 oz., and by cyanide 44,340 oz., making a total of 93,024 oz., selling for £488,046, of which £97,408 accrued from premium. The working cost was £464,067, leaving a working profit of £23,978.

Premier (Transvaal) Diamond Mining. — This company has worked diamond pipes north of Pretoria since 1902. Barnato Brothers obtained control in 1912, and, since 1917, the Premier and De Beers have been in a joint control. The report now issued covers the year ended October 31, 1921. Mining and washing operations were restricted to two shifts per day of 8 hours each, from November 1, 1920, to February 27, 1921; thence to June 30 only one shift was worked; from June 30 onward only five shifts per week. The amount of ground hoisted was 1,996,981 loads of 16 cu. ft. each. The yield of diamonds from the treatment of this ground was 411,981 carats, being a yield of 0·211 carat per load. During the normal year of 1920, the ground treated was 4,660,498 loads, the total yield of diamonds 820,564 carats, and the yield of diamonds per load 0·176 carat. The sale of diamonds during the year brought an income of £439,636, and other revenue amounted to £28,893. The working cost was £358,144, and £92,500 was distributed as preference dividend. Since the end of the company's year, the diamond market became still worse, but more recently the outlook seems a little brighter.

The Mining Magazine

W. F. White, *Managing Director.* Edward Walker, M.Sc., F.G.S., *Editor.*

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CONTENTS

EDITORIAL

IT is announced that the annual dinner of the Royal School of Mines Old Students' Association will be held at Gatti's Restaurant, Strand, on May 19, and that the annual meeting of the Association will be held on the same day at 12 noon at the Mining and Metallurgical Club.

THE usual holiday course in economic geology organized by the Camborne School of Mines is arranged for the six weeks July 17 to August 26 next. The course will comprise lectures, laboratory work, field mapping, visits to mines, and day excursions to the St. Austell china-clay district, Land's End, the Lizard, etc. The course is open to all, and the fee is six guineas. In previous years men from far and near have been attracted. Applications should be made to the Secretary of the School.

FINAL arrangements have been made for the holding of the Thirteenth International Geological Congress at Brussels in August. The meetings will occupy eight days from the 10th to the 19th of the month, and there will be numerous excursions a week before the meetings and a week or ten days after. The geology of Belgium will be the chief subject of study, but considerable time will also be devoted to Africa and China and to the geology of petroleum. Those desirous of attending should communicate with the Secretary of the Congress, Palais du Cinquantenaire, Brussels.

DISINTEGRATION of the atom has been before the public once more, both in England and America. Sir Ernest Rutherford, in his lecture before the Institute of Metals, showed that certain radium bombardments can produce hydrogen from a variety of other elements, and it may be argued therefore that the hydrogen atom is the ultimate constituent of all substances. In America Dr. Wendt has demonstrated that a fine wire of tungsten can be "exploded" into helium by the sudden discharge through it of electricity at an enormously high potential. Details of Dr. Wendt's experiments are not yet to hand; they are to be given in a forthcoming issue of the *Journal* of the American Chemical Society.

WHAT has no doubt seemed to most people a cryptic advertisement has been affixed to the walls of London streets and stations lately. This placard proclaims "Stibnites" in bold capitals. Many folks took the word for a dark horse at the races, spotted by an unusually intelligent tipster, but actually it was intended to attract the passer-by to the Museum of Practical Geology in Jermyn Street. Seriously we wish more was done to draw attention to the many valuable and interesting exhibitions in this old city of ours.

SOME time ago acetylene was recommended as a precipitant for precious metals from cyanide solutions. The United States Bureau of Mines has recently been investigating this suggestion and the claims of the patentees of the process. The chemists of the Bureau were unable to obtain a precipitation of gold, but the silver was fairly completely removed. The silver compound obtained did not, however, in any way resemble the acetelide, otherwise carbide, and on subsequent investigation the precipitate was identified as silver sulphide. They then analysed the acetylene that was being used, and they found a comparatively large amount of sulphuretted hydrogen in it. On preparing a pure acetylene and applying it to the silver cyanide solution, no precipitation of silver occurred, and thus it was proved that acetylene is not a precipitant of precious metals from cyanide solutions.

IN this issue we publish as a "Letter to the Editor" a contribution to the discussion on the value of gold by Mr. H. R. Sleeman. A paper on this subject by the same author has appeared in the *Journal-Press*, and Mr. Sleeman will also put the matter before the Institution of Mining and Metallurgy at the May meeting. It is highly desirable that this question should be discussed, and every argument put forward in favour of the case of the producer. But for ourselves we confess it is impossible to wax enthusiastic over any proposal for creating an artificial price for gold. If gold is not to be sold by its value in the market-place, we might as well go back to cowry shells or other tokens. It is possible that the controllers of the gold market and the exchange bankers get it too much their own way, but, at any rate, it is to their interest to encourage trade. On the other hand, the establishment of an artificial standard based on nothing very easily defined or determinable would deaden the wits of the present customers of the gold producers and place the control with a Government department which is already doing too much to cripple trade and industry.

The Institution of Mining and Metallurgy

Two of the usual yearly functions of the Institution of Mining and Metallurgy were held last month, firstly the dinner where members get into touch with eminent men outside the profession, and secondly the annual meeting, at which the official business of the Institution is transacted and the new president delivers his address. It is not easy to report the speeches at the annual dinner, for as a rule men who could give serious technical addresses are expected to depart from their metier and indulge in after-dinner oratory ; and severed from the correct atmosphere such speeches do not read well and do not lend themselves to the efforts of the precis writer. Suffice it to say that everyone enjoyed the addresses of Mr. W. C. Bridgeman, the Secretary for Mines, Lord Morris, vice-chairman of the Imperial Mineral Resources Bureau, Sir James Allen, High Commissioner for New Zealand, Sir Lionel Phillips, Sir Thomas H. Holland, and Sir John Cadman. In particular the members appreciated the remarks of the Secretary for Mines, who assured his hearers of the high value his Department placed on the advice of representatives of the Institution of Mining and Metallurgy and the Institution of Mining Engineers. They were also well pleased with his statement that his Department now understands that the health and safety of miners can be more satisfactorily attained by a minimum than by a multiplicity of regulations. The most serious speech of the evening was that of the president, Mr. F. W. Harbord, who reviewed the work of the Institution in advancing the honour and status of the members, both within the Institution itself and in their relations with the public throughout the world, while his expressions of opinion with regard to education and labour showed his grasp of modern scientific and economic requirements.

From one president to another is a short step, and the address of the new president, Mr. S. J. Speak, at the annual meeting of the Institution, deserves equal applause with that of Mr. Harbord. Incoming presidents have a wide choice of subjects for their address, and it often happens that the president will concentrate on a review of progress in his own particular line. Mr. Speak preferred to deal with the general welfare of the Institution, and he handled his subject in a concise and level-headed manner. It is not possible here to do anything like justice to his address, but it is desirable that all members and friends of the Institution should read it carefully when published in the Bulletin this month, and that it should be filed away as a standard statement of the aims and duties of the corporate mining engineer. There are one or two points, however, which deserve special note. One was his statement that the co-operation and working agreement between the Institution of Mining and Metallurgy and the Institution of Mining Engineers was an important step in the recent efforts to define the term " engineer " and to limit its use. The attempts of the Civils to define this term ended prematurely, owing to their institution arrogating to itself far too big a share in the decision of such questions. Mr. Speak mentioned that there is a probability of a " General Engineering Council " being established for the purpose of defining the term and of protecting all properly qualified engineers, and also for the purpose of correlating the work in this direction of the existing engineering societies. As Mr. Speak says, a combination of such a kind will attain its objects more effectively than any society acting singly, and in these days of political and economic strife the combination would serve as a powerful protection of the professional engineer.

Another point raised by Mr. Speak related to the ethics of the profession, and here his characteristic clear-sightedness was evinced by his view that any refined code of ethics rather implies a desire to dodge the moral law of common honesty. His words were : " The difficulty of framing a detailed code of ethics is that it might imply some disregard of the ordinary principles of honesty and integrity by its members." He proceeds to show that all questions relating to professional dealings can be solved perfectly easily without any resort to casuistry. Probably members will be wise to leave it at that, for as a rule those who spread themselves on a discussion on ethics as applied to the mining profession are better known for their preachings than their practice. But, by all means, see that the presidential addresses of Mr. Walter McDermott in 1897 and of Mr. Speak in 1922 have been read by the student and the young engineer before he embarks on his life's career.

One further item in Mr. Speak's address deserves notice. This is his reference to the necessity for some permanent link between the Institution and those who are interested in mining solely from the financial point of view. The Institution is a purely professional body, and neither it nor its members individually are in a position to control the finance of mining, to criticize specific promotions, or to take public action relating to taxation or national finance. On one occasion the Institution took joint action with a committee of business men in connexion with the incidence of income tax on mining operations, and it is likely that the Government will accept many of the recommendations when the promised new income tax law is prepared. If such a joint committee could be made a permanency in some manner, it would be all to the benefit of the mining engineer, but how to bring about its establishment is not quite clear. Possibly a Chamber of Mines is required, to work hand in hand with the Institution, and there are many difficulties to overcome before a representative and active Chamber can be established. Mr. Speak while on this subject briefly referred to the Institution taking steps to expose undesirable promotions, and pointed out that the Institution could not undertake such work, though a joint committee such as that proposed might be able to do so. While we should welcome such action, it is only right to say that great obstacles would present themselves to its adequate execution. For instance, the average engineer or financier does not care to pass public judgment on this class of scheme; secondly the preparation of an indictment by a committee would take so long that the damage would be done before its report could be published; and finally, the newspapers printing such a report would have to be safeguarded against the cost of libel actions.

The hope of the Institution is that all mining engineers of repute throughout the Empire shall join its ranks, and thereby bring the time nearer when a man shall not be allowed to call himself a mining engineer unless he is a member of the Institution. As the desire is that admittance to membership shall never be granted without due scrutiny, the Council and the Secretary are debarred from canvassing for members. The MAGAZINE can, however, and does, voice this aim and urge its general consideration.

Mr. T. A. Rickard and "The Mining Magazine."

Brief mention was made in our last issue of the amalgamation of the *Engineering and Mining Journal*, of New York, and the *Mining and Scientific Press*, of San Francisco, which took place on April 1. Since then the first four issues of the combined paper have reached this side, and it has been possible to judge of the tone, scope, and policy, and of the reasons for the amalgamation. It would have been congenial to us to be able to say pleasant things of the *Journal-Press*, for we have prized the *Engineering and Mining Journal* for many years under the editorial guidance of successive editors, the late Richard P. Rothwell, and Messrs. T. A. Rickard, W. R. Ingalls, and J. E. Spurr, and the *Mining and Scientific Press* under the control first of Mr. J. F. Halloran, and subsequently of Mr. T. A. Rickard. But our characteristic cheerfulness is qualified by the present attitude toward THE MINING MAGAZINE assumed by Mr. T. A. Rickard, who has become contributing editor of the *Journal-Press*, with an office on the Pacific coast. We do not relish being involved in unseemly wrangles, particularly with Mr. Rickard, and if we pick up the gauntlet and depart from our accustomed serenity of method, we must crave indulgence by quoting the schoolboy's definition of the badger as a "savage animal which defends itself when attacked."

The words to which we take exception are contained in an interview with Mr. Rickard published in the *Journal-Press* for April 1, and we quote them herewith in full:—

> If you want to see to what depth of depravity journalism can fall when it is subventioned and subsidized, you have only to go to London and see how such practices there have degraded the financial and mining journalism of that great centre.
>
> THE MINING MAGAZINE was started by me as an independent paper, and, I believe, did good work in its time, but to-day it is going the way of London financial and mining journalism, in that it is

becoming dependent more upon the so-called company-meeting advertisements than upon straight advertising from manufacturers of mining machinery. In other words, it is being supported largely by the mining companies—the promoters and directors—so that it is departing from the policy of frank and free criticism that made it worth while seven or eight years ago.

The primary purpose [of publishing the reports of company meetings] is publicity; the printing of the proceedings helps to keep the company in the public eye and so assists the market for its shares; the secondary purpose is as a sop to Cerberus, to disarm the financial press. The purchase of space by the company for the report of its meeting, as for its prospectus when it is incubated, has the effect of silencing criticism and of eliciting compliment. The practice gives the promoter and company-monger a control of the papers that are venal, or even complaisant.

These paragraphs contain by implication a serious accusation against the MAGAZINE, an accusation lightly enough made, though not for a minute believed by people who take the trouble to read our pages. To put matters in their true perspective it is desirable to say that the inclusion of company meeting reports in the advertising pages was commenced when Mr. Rickard was controller and editor of the MAGAZINE; if there are more of these pages now than in his time, it is also true that there are more advertisements of mining machinery. We invite Mr. Rickard to point out any specific mining-company advertisement in our pages that should not have been inserted, or any offending paragraph that partakes of the nature of an unjustified puff or of an emasculated criticism. Our managing director, Mr. W. F. White, who is also the chief proprietor of the MAGAZINE, is well-known in the City for his refusal to do business with promoters of doubtful character, and for his determination to eliminate from the MAGAZINE all advertisements relating to shady transactions. Mr. White has something to say on this subject in answer to Mr. Rickard in a succeeding article. As far as criticism in the editorial pages is concerned, we do not admit that there is less helpful criticism now than formerly, but there is certainly less nagging and, we hope, fewer unkind personal remarks.

We are aware that the airing of personal matters in the pages of a technical paper is always an undignified proceeding, and especially so in the case of the past and present proprietors and editors of the paper. For this reason we have confined our remarks to a self-defence against an unwarranted attack; we have not attempted to carry the warfare into the enemy's country.

Et tu, Brute?

In the *Engineering and Mining Journal-Press* of April 1 Mr. T. A. Rickard, who was editor of THE MINING MAGAZINE from September, 1909, to March, 1915, in the course of an interview, stated:—

THE MINING MAGAZINE was started by me as an independent paper, and, I believe, did good work in its time, but to-day it is going the way of London financial and mining journalism, in that it is becoming dependent more upon the so-called company meeting advertisements than upon straight advertising from manufacturers of mining machinery. In other words, it is being supported largely by the mining companies—the promoters and directors—so that it is departing from the policy of frank and free criticism that made it worth while seven or eight years ago.

This statement so far as it concerns ourselves is untrue. Reference is made by Mr. Rickard to the dependence of the MAGAZINE more on company meeting advertisements than upon straight advertising from manufacturers of mining machinery, but he evidently forgets that the company meetings section was incorporated in the MAGAZINE by himself in October, 1909, and was continued during the whole of the period he remained connected with it. In inserting reports of company meetings in the advertising pages of the MAGAZINE we are, therefore, following in the footsteps of Mr. Rickard.

As to what Mr. Rickard calls "straight advertising from manufacturers of mining machinery," I may say that whereas for the five years 1909-1914—when Mr. Rickard was associated with the MAGAZINE—this averaged 277 pages per annum, for the five years 1916-1921—after Mr. Rickard had returned to the United States—the average was 444 pages per annum. These figures can be left to speak for themselves, evidencing as they do the view held by manufacturers of mining machinery as to the value of the advertising pages of the MAGAZINE.

With regard to the independence of the MAGAZINE, Mr. Rickard has on a previous occasion been informed that more communications from solicitors have been received at this office since he left than were received before, thus showing that there has been no falling off in criticism since his departure.

Knowing the facts—and Mr. Rickard is not unacquainted with them—the only explanation of Mr. Rickard's attack on THE MINING MAGAZINE is that it has proved successful, notwithstanding he is no longer associated with it.

W. F. WHITE, *Managing Director.*

REVIEW OF MINING

Introduction.—In this country industrial conditions are rather better, as the shipbuilders have gone back to work, though there is still a lock-out in engine shops. The Russian problem has been discussed at the Genoa Conference, and all sorts of rumours have been afloat relating to oil and metal concessions in that country. A partial agreement between Germany and Russia has caused dismay among other countries. As regards the finances of Great Britain, there is to be relief in income tax and postage charges. The metal markets continue weak, excepting in lead, where prices have been firmer, though this unfortunately was only caused by a strike at Spanish mines.

Transvaal.—The industrial position is settling down, and the Rand Mining Industry Board is hard at work studying costs, labour conditions, and other items connected with the economics of gold mining. Our space is extensively occupied this month with reports for 1921 of the mines on the Rand, and as usual it has been necessary to hold over the notices of many of the mines until next month.

The report of New State Areas for 1921 contains information as to the results of development and also a brief outline of the metallurgical plant to be erected. The two shafts are completed and equipped, the north being 3,768 ft. deep and the south 4,071 ft. The main connecting drive should be finished about mid-year. In the southern section the results of development were uniformly good, but the ground so far opened to the north-west of the northern shaft is poor. The treatment plant is to have a capacity of 50,000 tons per month. The ore will be reduced to $2\frac{1}{2}$ in. in jaw-breakers, and afterward to 1 in. in disc-crushers, passing thence to tube-mills. There will be 13 of these tube-mills, and their dimensions will be 20 ft. by 6 ft. 6 in. Each will have a Dorr classifier with independent circuit. The ore will be all-slimed in cyanide solution, and will be treated in Brown agitators, the solution subsequently passing through Butters filters and Merrill precipitation machines. It will be noted that stamps and amalgamation are eliminated.

The development of West Springs continues to be hindered by extensive faulting. In July and August last year we mentioned that the sinking of No. 2 shaft was suspended and resort was being had to diamond-drilling. This drilling has since indicated that the reef will be found at a depth of about 4,800 ft., but work in this quarter is stopped for the time until further funds are available. Recent operations have been centred on No. 1 shaft and the area connected with Springs Mines. Here, again, the faulting has been a troublesome feature, and the reef was exposed for only a small part of the total driving along the main haulages. Where it has been possible to test the reef in stretches of ore, the assay-values have been encouraging.

Notice has been issued that the Roodepoort United is to be closed before long. Mining operations are confined to a few sections where the best ore is being reclaimed, and when this has been extracted mining and milling will be suspended. Very fair dividends were paid by this company from 1894 to 1898, and the rate was smaller during the years thereafter until 1910. Since then no profit has been made, and there is a debt of £365,782 owing to the General Mining and Finance Corporation.

The directors of Luipaard's Vlei are putting before their white workers a co-partnership plan, by means of which a resumption of operations may be possible. It is proposed that the men shall have pre-war wages, and that after £850 per month has been allocated to debenture service and £1,000 taken as profit, the wages shall be increased 5% for every £500 further profit made. This offer is to hold good only as long as the basic wage shall remain below the general average of the Rand.

In his reports on the various gold-mining companies of the Barnato group, Mr. J. G. Lawn draws attention to the heavy freight charges on the South African railways and the consequent increase in the cost of all material required by the mines. For instance, freight represents 60% of the cost of both coal and timber, and seeing that there is no long haulage the price paid for carriage is out of all proportion.

Diamonds.—The various diamond ventures of Mr. W. E. Bleloch in Griqualand West, 100 miles or so west of Kimberley, are being amalgamated as the Diamond Fields of Africa Exploring Co., Ltd., and 300,000 shares of 2s. 6d. each are being offered to the public for subscription. The individual mines are the Makganyene, Postmas, Bowden, and Smuts, and they have been examined by Mr. H. Olver and Dr. Merensky, who report that the ground is of the nature of true diamond pipes. The prospectus, however, does not give very much information.

Rhodesia.—The output of gold during March is reported at 54,643 oz., as compared with 51,422 oz. in February, and 31,995 oz. in March, 1921, the time of the strike. Other returns for Southern Rhodesia were: Silver, 14,376 oz.; coal, 39,741 tons; copper, 273 tons; asbestos, 437 tons; arsenic, 85 tons; and mica, 1 ton.

West Africa.—At the meeting of the Obbuassi Mines, Ltd., held early this month, Mr. C. W. Catt, the new chairman, announced that a promise of further working capital had been received. This company has worked the Obuom concession on a very limited scale during the last 2½ years, and capital was badly wanted for the purpose of extending development. A ten-stamp mill has been running continuously and a cyanide plant is on its way out. Mr. D. J. Macdonald, the consulting engineer, reports hopefully of the property.

Australia.—The iron and steel works of the Broken Hill Proprietary, at Newcastle, New South Wales, are gradually closing as current orders are completed. The coke-ovens and blast-furnaces are already idle. Two of the steel furnaces have stopped, and the third is expected to finish about the middle of this month. The whole plant will then be closed, and no talk of reopening can arise until the high cost of coal and wages comes down.

India.—The reports of the gold-mining companies in the Kolar district of Mysore, controlled by Messrs. John Taylor & Sons, present a variety of reading. The most welcome news comes from Ooregum, the deepest of the series, where, at over 6,000 ft. vertical, the developments are giving excellent results, while the output of gold for 1921 is the largest on record. At Mysore the developments have been fairly satisfactory, but the grade has been low during the last few years, and the output of gold has depended considerably on the treatment of old residues. At Nundydroog the developments have been rather disappointing, and unless ore of higher grade is found soon, the ore sent to the mill will show a fall in content before long. The Champion Reef report has been issued so soon after the reconstruction that little can be said of increased development at depth; most of the work has been concerned with the provision of means for an improvement in ventilation.

The Cordoba Copper Co., which used to operate in Spain, is now developing copper lodes in Chota Nagpur, India, in the neighbourhood of the properties of the Cape Copper Co., from whom the company obtained the options. The reports show that three lodes have been proved, averaging from 2 to 8% over about 3 ft., the lodes being of much the same nature as those at the Cape Copper Co.'s mines. The test workings are only shallow as yet, and further exploration at depth is being undertaken in order that the value of the lodes as mining propositions may be ascertained.

Burma.—The Indo-Burma Oilfields Company announces that pumping was commenced on the Yenanma field on January 12, and at Paduakpin on March 7. The total output to the end of March was 2,707 tons. The refinery started operations on March 15. A co-operative scheme has been arranged with another oil company to extend the drilling campaign, the other company to provide the funds and take one-third of the profits after repayment of the cost. In this way the Indo-Burma company will avoid having to raise additional working capital.

Malaya.—Owing to the labour troubles in England, the second dredge for Tekka-Taiping was considerably delayed in delivery, but everything is now on the spot and a start may be expected shortly. No. 1 dredge has been passing through a belt of poor ground lately, and the average extraction per yard during the past year was only 0·64 lb. This yield, however, was 14% higher than was provided by the figures from the bores. The output for the year ended October 31 last was 266 tons, as compared with 395 tons the year before, and the profit was £7,546 as compared with £43,802.

A china-clay industry has been established at Gopeng in the State of Perak by the Malayan China Clay and Pottery Company. Pottery is already being made, and the contracts for the clay have been secured from cotton mills and paper works in India. Dr. W. R. Jones, an ex-member of the Geological Survey of the Federated Malay States, and more recently connected with the Burma wolfram production, is a moving spirit in this enterprise.

Cornwall.—Particulars of the progress of East Pool and Agar are given elsewhere in this issue, together with details of the arrangements for the provision of additional capital for shaft-sinking. The new shaft was down 300 ft. at May 1.

A petition for the winding up of Calloose

Tin Mines and Alluvials, Ltd., Mr. A. F. Calvert's promotion which we often criticized in 1919 and 1920, is to be heard in the High Court on May 16.

It is stated that the Government is being advised to grant financial help in the way of loans to certain Cornish mines. South Crofty is mentioned as being recommended an advance of £30,000 for the purpose of providing an adequate pumping plant, and it is believed also that the Levant is to be helped. No official announcement has yet been made.

Canada.—In February we mentioned that the American Smelting and Refining Co. had acquired minority holdings in the B.C. Silver Mines, Ltd., which owns property adjoining the Premier gold mine in northern British Columbia. The American Smelting and Refining Co. has developed the Premier into one of the most remarkable mines of the day, and is anxious to acquire the ground containing the continuation of the lodes. The B.C. Silver Mines, Ltd., is controlled by the Selukwe Gold Mining and Finance Co., an English company hitherto operating in Rhodesia, the interest in it having been acquired on the recommendation of Mr. C. A. Banks. It is now announced that the Selukwe has acquired the balance of the unissued capital, namely 259,100 shares, so that the company now holds 879,599 shares against the American company's 620,401 shares. The capital now provided will be spent in driving an adit and conducting a diamond-drilling and general development campaign.

Mr. W. H. Goodchild has given his views as to the new ore-body at Tough Oakes, now being developed by Kirkland Lake Proprietary. The ore consists of mineralized porphyry impregnated with free gold and telluride of lead. The latter mineral is characteristic of the central ore zone of the Kirkland Lake goldfield, and this mineralization together with the position of the ore-body prove that the latter is the continuation of the main lode on which the leading mines of the district are situated. This ore-body, though it does not reach the surface, may be expected to continue strong in depth, and Mr. Goodchild advises the immediate sinking of the shaft to at least 1,000 ft.

United States.—The production of refined lead from home ores during 1921 is estimated at 398,222 tons, and from foreign ores 50,367 tons, making a total output of 448,589 tons. The home consumption is estimated at 444,872 tons. The figures for 1920 were respectively 476,849 tons, 52,808 tons, 529,657 tons, and 538,020 tons. There was also produced 10,064 tons of antimonial lead, as against 12,535 tons the year before.

Last November we recorded that the Anglo-United Oilfields, Ltd., operating in Wyoming, was reconstructed in order to provide new capital required owing to the fall in the price of petroleum. It is now announced that this reconstruction was successful to a certain extent, enough money being raised for the purpose of liquidating debts and protecting the properties. Sufficient money, however, was not received for it to be possible to resume drilling and production. It has therefore been decided by the board, and approved by shareholders, to sell the property to the Derby Dome Wyoming Oil Co., which owns adjoining land. The purchase will be satisfied by the issue of shares in the Derby Dome Company. The latter company is in a position to provide funds for working capital, and it already has a large number of English shareholders. Mr. Campbell Hunter has reported favourably on this new scheme.

Venezuela.—Cable reports have been received from Mr. C. H. Stewart, of the firm of Alexander Hill and Stewart, as a result of his investigation of the Aroa copper mines belonging to the South American Copper Syndicate. He confirms the estimate of the reserve at 600,000 tons of ore, averaging over 5%, and reports that 5,000 tons per month can be delivered immediately. The new smelter is in course of delivery. Mr. Stewart also expresses his opinion that the new ore-body will very likely provide an important addition to the reserve.

Spain.—At the meeting of the Rio Tinto shareholders, Sir Charles Fielding spoke fairly hopefully of the eventual revival of copper in general and of the company's fortunes in particular. Though he did not express any great expectations for 1922, he spoke of his moderate optimism for the succeeding year. The accumulations of war stocks are far from being disposed of, and there are comparatively few mines where the costs are below the present price. That he should expect an increased demand and price during the next year or so reflects the general impression that better times are coming slowly but surely. Mr. W. P. Rutherford, presiding at the Tharsis meeting, spoke in much the same strain.

THE DETERMINATION OF ALUMINIUM BY THE PHOSPHATE METHOD

By J. E. CLENNELL, B.Sc., Assoc.Inst.M.M.

INTRODUCTORY.—In the following notes it is proposed to give a brief summary of the writer's experiments, made at the Royal School of Mines, February to October, 1920, on the phosphate method of aluminium estimation.

The method in its ordinary form is well-known, and need not here be described in detail. It depends on the precipitation of aluminium as phosphate and simultaneous reduction of iron to the ferrous state by means of a soluble phosphate and thiosulphate, in a very faintly acid solution, to which acetic acid is added at some stage of the treatment, the iron and most other metals remaining in solution. A brief account of this method was given in a former article by the present writer in the MAGAZINE for February, 1920.

LITERATURE OF THE PROCESS.—Published accounts of the method differ in many of the details. The following may be consulted :—

J. E. Stead : *Journ.* Society of Chemical Industry, 1889, p. 965.

A. Carnot : *Moniteur Scientifique*, 1891, p. 14.

A. H. Low : " Technical Methods of Ore Analysis," 5th ed. (1911), pp. 20–25.

Ibbotson and Aitchison : " Analysis of non-Ferrous Alloys " (1915), p. 139.

A. A. Blair : " Chemical Analysis of Iron," 8th ed. (1918), p. 190.

Lord and Demorest : " Metallurgical Analysis," 3rd ed., p. 295.

Rhead and Sexton : " Assaying and Metallurgical Analysis," 2nd ed., pp. 345, 346, 380, 381.

ADVANTAGES AND DISADVANTAGES.—The phosphate method presents several obvious advantages over the more commonly used forms of the oxide method. The precipitate comes down in a form which may be rapidly filtered and washed, being flocculent rather than gelatinous. Iron is kept in solution, provided sufficient acetic acid be present. Glass and porcelain vessels are not attacked, since precipitation takes place in an acid medium. The ignited precipitate is not appreciably hygroscopic. A further advantage is that the weight of precipitate obtained from a given weight of aluminium taken is about 2½ times that of the oxide.

In practice, however, several drawbacks present themselves. The preliminary neutralization of the solution is an important point, as very slight variations of acidity materially affect the result, and there is no suitable indicator of the correct acidity, except the point at which the turbidity given by the phosphate just disappears on gradual addition of dilute acid.

Another difficulty arises in the boiling operation. A very bulky precipitate begins to form and to settle on the bottom of the flask or beaker, which causes violent " bumping," projecting the contents and often breaking the vessel. This can only be avoided by continued agitation until boiling has thoroughly started, necessitating a special agitating device where many assays are to be run at a time.

The ignition also presents some difficulties, which, however, are easily overcome by a suitable procedure. Too sudden exposure to a high temperature before the filter paper has completely burnt away results in fusion of the precipitate and contamination with carbon, which can only be removed by very prolonged ignition at a high temperature or by evaporation with nitric acid.

The most serious objection to the method, however, results from the circumstance that the ignited precipitate finally obtained is not of constant composition. This point has been generally overlooked by writers on the subject, although Ibbotson and Aitchison (loc. cit., p. 140) remark as follows : " The large excess of phosphate introduced (2 or 3 grm. of sodium phosphate for 100 mgr. of aluminium) appears to be necessary in order to secure the formation of a phosphate of definite composition, experience having shown that while smaller quantities may yield a complete removal of the aluminium from the solution, yet the precipitate containing it is of indefinite composition." In the writer's experience, a very much larger excess is needed.

POINTS INVESTIGATED.—In view of the differences noted in the various published descriptions of the process, the following points appeared to require investigation :—

(1) Effect of varying relative amounts of different reagents, particularly of soluble phosphate, used in determination.

(2) Effect of varying acidity at moment of precipitation.

(3) Effect of varying order in which reagents are added.

(4) Effect of varying temperature at which precipitation begins.

(5) Effect of re-dissolving and re-precipitating the original phosphate precipitate.

(6) Completeness of the precipitation, as shown by examination of the filtrate by various methods.

(7) Effect of foreign elements, such as iron, zinc, etc.

(8) Examination of the precipitate itself to determine the nature and amount of impurities present, and actual composition: that is, the ratio of Al_2O_3 to P_2O_5 in the final precipitate.

It is impossible to give a detailed account of the very numerous experiments made on these points; we shall here state only the general results and give a short description of the method finally adopted.

Material used for Tests.—Most of the experiments were made on the purest obtainable metallic aluminium, which showed by difference, after determining the small amounts of silicon, iron, and other impurities, about 99·7% of aluminium. In general 100 mgr. was taken for each test. Some tests were also made with pure ammonia alum, of which the aluminium content had been determinied as precisely as possible by precipitation as hydroxide and ignition to Al_2O_3.

Effect of Varying Phosphate.—In most cases the figures given in the tables *a*, *b*, and *c* in the next column represent the mean of several determinations. Slight variations in the details of treatment and the nature of the samples may account for some apparent discrepancies.

Since 100 mgr. of 99·7% Al should yield 0·4492 grm. $AlPO_4$, it is evident that the precipitates obtained in the above tests usually differ widely from this composition. Actual analysis showed that the difference is due to an excess of P_2O_5, which increases more or less regularly with increasing amount of phosphate used, up to a certain point, beyond which there are irregular variations, but no continuous increase. With sodium phosphate this limit probably lies somewhere near 25 grm. per 100 mgr. of Al, but in the case of ammonium phosphate it appears to be about 4 grm. It was at first thought that the excess weight over the theoretical for $AlPO_4$ might be due to the retention of some impurity, for example,

(*a*) *Sodium Phosphate* Na_2HPO_4, 12 H_2O.

Weight of Phosphate *grm.*	*Weight of Precipitate per* 100 *mgr. of Al* *grm.*	*Apparent Percentage of aluminium based on the formula* $AlPO_4$
1·5	0·4269	94·7
2	0·4577	101·6
3	0·4570	101·4
4	0·4813	106·8
5	0·4966	110·2
7	0·5028	111·6
10	0·5248	116·5
12	0·5312	117·9
15	0·5380	119·4
20	0.5426	120·4
25	0·5608	124·4
30	0·5632	125·0

(*b*) *Ammonium Phosphate* $(NH_4)_2HPO_4$.

Weight of Phosphate *grm.*	*Weight of Precipitate per* 100 *mgr. of Al* *grm.*	*Apparent Percentage of aluminium based on the formula* $AlPO_4$
0·5	0·4235	94·0
1	0·4563	101·3
1·5	0·4781	106·1
2	0·4783	106·1
3	0·4863	107·9
4	0·5031	111·6
5	0·5012	111·2
6	0·5065	112·4
8	0·4959	110·0
10	0·4935	109·5

(*c*) *Microcosmic Salt.* (Sodic-ammonic phosphate).

Weight of Phosphate *grm.*	*Weight of Precipitate per* 100 *mgr. of Al* *grm.*	*Apparent Percentage of aluminium based on the formula* $AlPO_4$
2	0·4949	109·8
5	0·5041	111·9
7	0·5155	114·4
10	0·5351	118·7

sodium sulphate or phosphate. A number of tests made exclusively with ammonium salts, substituting ammonium thiosulphate for the sodium salt, yielded, however, similar results.

Blank tests on the reagents showed quantities of impurity which would affect the result only by a fraction of 1%, and the correction indicated (about 0·0012 grm.) has been made on the results quoted above.

In some determinations the solutions were carefully freed from silicon, iron, and copper by preliminary operations, but the same large excess over the theoretical weight was still obtained.

Effect of Varying other Reagents.—Varying the amount of sodium thiosulphate between 5 and 10 grm. did not affect the result, but since an excess of thiosulphate corrects the effect of a small excess of acid, it is perhaps desirable to use not less than 7 grm. in a test on 100 mgr. of aluminium.

Acetic acid was varied between 10 cc. and 50 cc. of glacial acid, without apparent effect.

EFFECT OF VARYING ACIDITY.—The following figures illustrate the effect of increasing the amount of hydrochloric acid above the quantity required to produce exact neutrality, in the solution prepared for precipitation, before adding thiosulphate or acetic acid. 100 mgr. of Al and 5 grm. sodium phosphate were used in each test. Examination of the filtrates showed that the unprecipitated aluminium could be recovered by further addition of thiosulphate alone, in test No. 4, and of ammonia and thiosulphate in tests 5 and 6. Apparently a small excess of acid tends to increase the weight of precipitate obtained.

Test No.	*Excess of HCl (20% by volume)* cc.	*Weight of Precipitate* grm.	*Aluminium based on $AlPO_4$* per cent
1	*nil*	0·4493	99·7
2	5	0·4575	101·7
3	10	0·4547	100·9
4	15	0·2893	64·2
5	25	0·0020	0·4
6	50	0·0009	0·2

EFFECT OF VARYING MODE AND ORDER OF ADDING REAGENTS.—It was found that the result was practically the same whether an excess of ammonia was added to a clear solution containing aluminium, hydrochloric acid, and a soluble phosphate, and the precipitate thus formed cleared by addition of dilute HCl, or whether the precipitate formed by adding a soluble phosphate to an aluminium solution slightly acid with hydrochloric acid was cleared by further addition of dilute HCl without using ammonia.

No difference was noted whether the phosphate was added to a hot or cold solution. There was also no distinct difference whether the solution was boiled before or after the addition of the required amount of thiosulphate, provided excess of SO_2 was finally boiled off. When a cold solution, containing aluminium phosphate dissolved in a minimum of acid, without thiosulphate, is heated to boiling, a precipitate occurs. This requires to be dissolved in acid before addition of thiosulphate. If, however, the thiosulphate be added to the cold, neutralized solution of aluminium phosphate, a turbidity forms almost at once, which increases on boiling to a dense precipitate. The final weight of ignited precipitate, however, is the same in both cases.

Slightly higher results were obtained when acetic acid was added to the cold solution before adding thiosulphate than when added to the boiling solution after thiosulphate.

EFFECT OF DISSOLVING AND REPRECIPITATING THE FIRST PHOSPHATE PRECIPITATE.—This procedure is recommended by most writers on the subject, but it is not always clearly stated whether further amounts of phosphate are to be added in the second precipitation. The writer finds a radical difference in the result according as soluble phosphate is added or not in reprecipitating.

When the soluble phosphate is omitted, the precipitate, as thrown down from a slightly acid solution by sodium or ammonium thiosulphate, or by ammonium acetate, has a different character from the first precipitate, and weighs much less, although the precipitation of aluminium may be complete. In presence of sufficient soluble phosphate, the new precipitate is of the same general character as the original, but not necessarily of the same weight. These observations disclosed the existence of at least two distinct forms of aluminium phosphate, which have the following characters :—

(*a*) Obtained when precipitated from a slightly acid solution in presence of a sufficient excess of soluble phosphate, or when reprecipitated with excess of phosphate. Comes down mixed with sulphur, is flocculent, settles and filters rapidly, yields on ignition a white chalky powder, not hygroscopic and sometimes not completely soluble in dilute mineral acids (suggesting that the product in not really homogeneous). Probably an acid phosphate. The portion soluble with difficulty in acids was found to contain a slightly higher percentage of P_2O_5 than the remainder.

(*b*) Obtained when little more than the theoretical amount of phosphate has been used to precipitate Al as $AlPO_4$ (say, 1·5 grm. of $Na_2HPO_4,12H_2O$ or 0·5 grm. of $(NH_4)_2HPO_4$ per 100 mgr. of Al), or when the first precipitate is redissolved in HCl and reprecipitated without further addition of soluble phosphate, as described above. Bulky, gelatinous, very difficult to filter and wash. Settles slowly. The ignited precipitate has a faint reddish tinge, is sometimes vitreous, and decidedly hygroscopic. It is readily soluble in dilute mineral acids, and appears to be a basic phosphate.

A precipitate corresponding precisely to the formula $AlPO_4$ is produced only under exactly defined conditions, which it is difficult to reproduce unless the aluminium content of the substance analysed be accurately known beforehand. Using 100 mgr. of pure Al and proceeding as detailed later, the quantities 1·9 grm. of sodium phosphate or 0·9 grm. of ammonium phosphate will give about 0·4506 grm. of ignited precipitate, corresponding to the neutral phosphate $AlPO_4$.

Examination of the Filtrate.—Examination of the filtrate showed that whatever method of precipitation or proportion of phosphate to aluminium was adopted, a small portion of aluminium remained unprecipitated. Most of this can be recovered by the method recommended by Low (loc. cit.), namely, by repeated boiling and filtration on small separate filters, until the extra precipitate no longer shows a residue on ignition. Some sulphur is always thrown down, so that ignition is necessary to demonstrate the absence of aluminium. This method, however, is troublesome and tedious, and in the writer's experience is liable to cause precipitation of iron and other impurities, if continued until most of the acetic acid has been expelled. The writer finds that all but a negligible amount may be recovered by settling the precipitate, decanting the almost clear liquid through a filter, boiling the filtrate for a short time, and passing again through the same filter till clear. The bulk of precipitate may then be collected without using a second filter.

Influence of Impurities.—Silicon and copper, if in appreciable amount, must in all cases be removed by preliminary operations. Most of the metals present in ordinary alloys pass into the filtrate, but it was found that small quantities of these, particularly of iron and zinc, are persistently retained in the precipitate. Nevertheless, the weight of precipitate obtained, when these metals are present, is generally less than that obtained when the same amount of aluminium is taken without the impurities. This may be due to the formation of aluminium phosphate, containing less P_2O_5, owing to the combination of part of the P_2O_5 with the foreign metal. The phosphates of the latter are soluble under the conditions of precipitation, but small amounts seem to be absorbed or retained mechanically by the aluminium phosphate precipitate.

Composition of the Precipitate.—Analyses of the precipitate itself were made, including determinations of the phosphoric acid (P_2O_5) by a modification of the molybdate method described by the author in a former article (The Mining Magazine, March, 1921). These confirmed the conclusion that the precipitate formed in presence of a considerable excess of phosphate is an acid phosphate of aluminium containing more P_2O_5 than indicated by the formula $AlPO_4$, and that the precipitate formed by a very small excess is a basic phosphate containing less P_2O_5 than indicated by $AlPO_4$.

Modified Process of Aluminium Estimation.—These experiments clearly demonstrate that the weight of precipitate alone cannot be depended upon as an indication of the amount of aluminium present. A uniform system of precipitation must be adhered to, and, as nearly as possible, a known ratio between the amounts of aluminium present and soluble phosphate taken. The following method was adopted by the writer as a standard :—

Dissolve 100 mgr. of the nearly pure metal, or, in the case of impure alloys a quantity known by preliminary rough tests to contain about 100 mgr. of Al, in the requisite acids. Frequently, 10 cc. of hydrochloric acid, 50% by volume, will suffice. In other cases a little nitric acid is needed. Filter if any insoluble matter is found. Remove copper if necessary by precipitation with H_2S. To the solution, now free from interfering metals, add 5 grm. of sodium phosphate or 2 grm. of ammonium phosphate. If a turbidity is formed add hydrochloric acid till clear. In any case add ammonia till decidedly alkaline, then dilute hydrochloric acid (20% by volume) gradually with agitation, till a clear solution is formed. Then add 20 cc. of acetic acid (glacial) and 7 grm. sodium thiosulphate. Dilute to 300 cc. Heat to boiling with constant agitation. Boil continuously for at least 30 minutes. Settle 5 minutes. Filter on 11 cm. paper, boiling and refiltering the first filtrate as already described. Wash with hot water till free of chlorides and thiosulphates. (No double precipitation or further treatment of the filtrate is necessary.) Dry precipitate on the paper for a little while in a steam bath. Transfer paper with precipitate to a weighed porcelain crucible. Char at a low temperature at first ; finally ignite at a moderate red heat till residue is quite white. Cool in desiccator and weigh. The amount of aluminium is then calculated from the results of previous determinations with known quantities of pure metal under the same conditions, since the precipitate is not a definite compound.

STANDARD SUBSTANCES.—In these tests the writer used either the purest obtainable metallic aluminium in the form of fine drillings, or re-crystallized ammonia alum, taking a quantity of the latter containing as nearly as possible 100 mgr. of aluminium.

Ammonia alum has the advantage as a standard, of containing only about 6% of aluminium, so that a given degree of accuracy in weighing out the portion for a test gives the required weight of aluminium (namely 100 mgr.) more exactly than if pure metal be used. The same error in weighing, say, 1·6 grm. affects the result less than in weighing 100 mgr. The alum is, moreover, directly soluble in water, so that no preliminary acid treatment is necessary.

Duplicate determinations by the method given above showed closely concordant results, but in the case of impure alloys it it recommended that impurities should be added to the standard substance in the control tests corresponding in nature and amount with those found in the actual alloys, since these may influence the weight of precipitate formed.

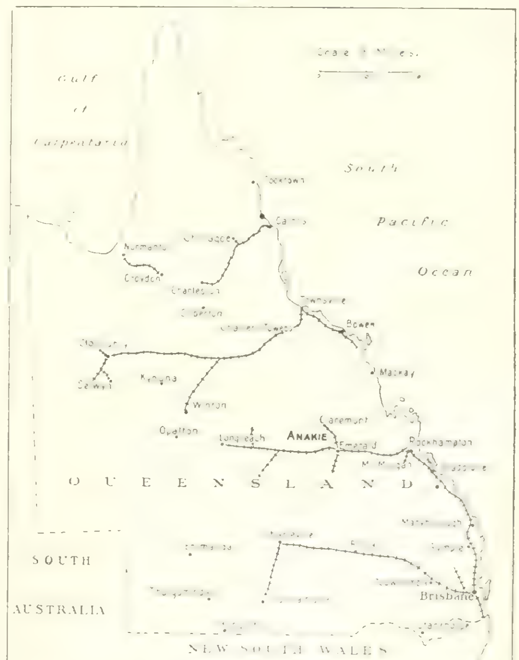
The writer has much pleasure in acknowledging the facilities granted and encouragement given by Professor Carpenter and the staff of the Royal School of Mines during the execution of these researches.

QUEENSLAND'S PRECIOUS STONES

The Author of this article, who has an intimate knowledge of the minerals of Queensland, gives herewith a description of the local gem-mining industry, which like many other mining enterprises is under a cloud at present.

INTRODUCTION.—For a very large proportion of all communities precious stones have a special fascination, and anything about them in the current literature of the day is read with keen interest. Even the individual who cannot indulge in the luxury of possession likes to know all that can be told him concerning these enticing articles of personal adornment, while the thirst in this direction of the more fortunate connoisseur who can afford to indulge his fancy is still greater.

In Queensland, the large State occupying that portion of the northern part of Australia having the Pacific Ocean for its eastern boundary, many kinds of gemstones, many of them highly prized, have been found. These include sapphires occurring on the Anakie mineral field in the central district; opal over large areas of the trackless far west; the diamond in the Stanthorpe district near the southern border, at Anakie, and at Gilberton in the far north; garnet in many localities; olivine on the main coastal range near Toowoomba, about 80 miles west of Brisbane; ruby in the leads of some of the old goldfields; topaz associated with the wolfram deposits of the north and with tin, sapphires, and gold in nearly all the drift deposits of the eastern part of the state; and zircons in association with gold, tin, and sapphires, and in many of the beach sands of the coast, the localities mentioned covering an area extending from near the southern boundary northward for more than 800 miles over the eastern and western parts of Queensland.



MAP OF QUEENSLAND.

To the outsider it may perhaps appear that this big country is doing, or could do, something large in the way of supplying the world with all kinds of gems, but it must not be supposed that all of the precious stones mentioned, or even a majority of them, have been or are being mined on a commercial scale. While numerous finds of most of them have been made at different times in widely separated parts of the State, and while far more have been discovered than have ever been officially recorded, circumstances have never admitted of the systematic mining of any of these precious stones except sapphires and opal. Diamonds are of rare occurrence. According to Chief Government Geologist B. Dunstan, in his able work the *Queensland Mineral Index*, some clear diamonds from Stanthorpe have been cut into perfect gems, but others have been returned from the lapidaries only partly faced owing to the crystals being too hard to work in the ordinary way. The diamonds found at Stanthorpe, Gilberton, and Anakie, however, are nearly all well crystallized in modifications of the octahedron and triakis-octahedron, and make good cabinet specimens. For Queensland garnet, which is found as an alteration or contact deposit between granite and limestone in association with epidote, wollastonite, chert, magnetite, and hematite, there is little demand as gemstones, but a brownish-red pyrope found at Lowood, on the Upper Brisbane River, is described as worthy of attention. The search for topaz in the tin gravels of Stanthorpe and for olivines in the creek beds and gullies of the mountainous country around Toowoomba is a favourite pastime with holiday makers spending their vacations in those salubrious neighbourhoods. Of the former stones, transparent, colourless specimens in sizes sufficiently large to be cut into gems are common, and sometimes pieces are picked up several inches in diameter and quite flawless. Olivine, although common, is seldom found in pieces large enough to make a gem of sufficient weight to be valuable. Jacinth, the precious variety of zircon, is a common associate of the sapphire at Anakie, and Mr. Dunstan, who is a recognized authority on gemstones, says that these gems of beautiful colour and lustre and weighing over 30 carats each have been cut from stones from this field. While large quantities of agate have been found in the north near Gilberton, the comparatively low cost of the imported material prohibits the use of the local article.

There is no official record of the production of each of the different gems found in Queensland, the fact being that none is reported except sapphires and opal. The value of the sapphires found up to the end of 1920 is estimated at £440,140, and of opal at £180,000. It is safe to say, however, that these estimates are very much below the actual production.

Occurrence and Mining of Sapphires.—Although sapphires have been found in various parts of Queensland, their production in the State is now, and has been for a number of years, confined to the Anakie field, which, on account of its extent and the beauty and variety of its gems is second to none in the world. Apart from the value of the sapphires as gems, the corundum and sapphires found at Anakie are valuable for commercial purposes on account of their freedom from fractures, impurities, and granulations. The "machine" stones are chiefly made into small bearings and pivots for parts of machines and engines running at high speeds. The Anakie field is in the central district, 190 miles west by rail from the port of Rockhampton, which is about 400 miles north of Brisbane, the capital. The proclaimed field is over 20 square miles in extent. The existence of gemstones in this locality was officially reported as early as 1892, and ten years later the then Government Geologist, after examining the field, reported that "the total distance along which deposits are found is altogether about 15 miles. Of an area of 400 square miles examined, 50 square miles contain deposits carrying sapphires of more or less value." In 1905 an important development was the opening up of a second bed of the sapphire wash at a depth of 25 ft., from which excellent stones, freer from flaws than those nearer the surface and many of them of the most beautiful description, were being obtained.

The sapphires occur associated with corundum in old alluvial deposits. The corundum stones, usually less than an inch in diameter, are all distinct crystals, while crystals of coarse corundum have been found which contain sapphires in the centre, and sometimes perfect gemstones are thus obtained. While the sapphire deposits are widely distributed, they are nearly all confined to the granite country. The deposits occur on the banks of the creeks, and the gemstones are often found in the beds of these streams after a "fresh" or flood. On these occasions "all hands and the cook"—men, women, and children—turn out and search for the coveted stones.

Workings 40 ft. deep in Anakie Sapphire Field.

Washing Plant at Ruby Vale, driven by a 5 h.p. Oil Engine.

According to Mr. Dunstan, the present Chief Geologist, who wrote a comprehensive report on the field many years ago, the thickness of the sapphire wash in the different workings varies considerably, in some places being only a few inches, and in others amounting to several feet. The bottom is usually a reddish clay, resting on decomposed schists and slates, but sometimes below this red clay a rich bed of wash is found. Some of the workings contain only medium-sized boulders, while in others these boulders are too large to be removed by hand. Frequently the sapphire wash is so clayey as to need puddling before the gemstones can be extracted. Much of the wash, however, is loose, friable, and free from clay, and from this the sapphires are separated by dry sieving. In seasons of drought, of course, this dry sieving is much the preferable plan. It is interesting to learn from the geologist that as the older formations which constitute the bottom of the deposits vary in composition so does the colour of the deposits resting upon them. Thus where the bedrock consists of decomposed slates and schists the wash is inclined to be reddish ; where granite is present it is of a yellowish colour ; and where the basic and intrusive rocks are on the bottom it is almost black.

The latest official report on the Anakie sapphire field, made by another of the Queensland Government geological staff (Mr. L. C. Ball), was published a few years ago. Even at this time, so many years after the first discovery, the extreme limits of the field had not been set, as sapphires had been reported many miles to the south, east, and west. The outside fields, however, had not received thorough trials, and the diggers had kept to the ground within 8 or 10 miles of the original centre at Sapphiretown and to Ruby Vale, which is a later settlement a few miles away.

The deepest workings are not more than 40 feet from the surface, and the field is in the hands of holders of small claims who work them themselves. Larger combined efforts and the employment of capital would no doubt tend to economy of working, for which there is much scope, but with the high rate of wages ruling for miners only those holding the richest ground can employ labour, which is rarely engaged.

The digging, as described by Mr. Ball, consists of three stages, embracing respectively surfacing, or simply the removal and treatment of the soil ; deep surfacing, necessitating the removal of several feet of overburden that may or may not carry gemstones ; and the sinking of shafts through the overburden into the wash, the boulders and large pebbles in this wash being packed behind to prevent caving and to save unnecessary haulage.

In some of the claims all the gemstones are of large size, and where this is the case mechanical treatment of the wash is obviated by hand-raking, consisting of passing under the hand all the material broken down and examining it when dry before throwing it away among the headings. In other claims in shallow ground the wash is classified and reduced in a small circular sieve suspended from a tripod, but when the material has to be mined the practice is to use a double inclined stationary screen, the lower screen having a finer mesh than that below it. In that case only the middlings that pass through the upper and are caught by the lower screen are reserved for treatment in rotary machines. These machines, which are driven by hand, horse, or engine, consist of a circular iron pan, 5 ft. in diameter and 1 ft. deep, with circumferential feed and central discharge. The wash, thoroughly moistened, is stirred up by blades attached to four arms driven from a central shaft. The blades are so set that they throw towards the wall of the pan all heavy material, including the gemstones, the slime being allowed to escape through a central trap and pass to waste. A load of ordinary wash can be put through by three men in a quarter of an hour. The heavy material saved by the machine is roughly classified by hand in an ordinary circular sieve with a removable perforated hopper, and the gems are concentrated on the bottom of the sieve by subjecting it under water to peculiar vertical and side shakes. The sieve is then inverted on the ground, and the sapphires are picked out from the other pebbles on the surface of the truncated cone of gravel so formed.

Production and Marketing of Sapphires.—During each of the first two years of the existence of the Anakie field (1892 and 1893) sapphires to the value, as far as official records show, of about £4,500 were produced. For the six following years no output was recorded, but thenceforward there were improving returns, with fluctuations, until a value of £43,300 was reached in 1913. Then, during the war, there was a big slump. In 1918 the figures were £16,600, and in the following year a large jump to £42,883 occurred with a further big rise to £65,830 in 1920, the total to the end of 1920 being £440,140.

The Anakie sapphire field during the whole of its existence has had its ups and downs. Periods of depression, however, were not on account of any difficulty in obtaining gems, but have been due to market fluctuations and the impossibility sometimes of selling at remunerative prices. The miners as a body have never been satisfied with the prices obtained, and have ever seemed to hold the opinion that they were not getting a fair deal from buyers. Whether they were right or not is an open question. Before the war the demand was regulated almost entirely by the lapidaries of Germany, who had buying agents on the field and who distributed the cut material throughout Russia. While hostilities were in progress the field, as was to be expected, suffered from great depression, but in 1918, with an open market and a keen demand, prices rose to an unprecedented height, and a remarkably good period was experienced that extended into the first half of 1920, after which the demand for gems slackened very much. Early in 1921, the Government, responding to certain pressure, made an agreement with the firm of Rubin Brothers, of Paris, for the marketing of the gems. Under this agreement the firm named, which was given the sole right of purchase of the gems, were, through the Government, to advance 75% of the ruling price, and pay the balance, less commission and other charges, on their being sold. In one month (January) gems to the value of nearly £23,000 were purchased, but two or three months later the prices which Rubin Brothers were prepared to give were so low that the miners declined to accept them; notice for the termination of the agreement was given, and it has not been renewed.

Opal in Queensland.—The opal-bearing country of Queensland extends over an immense area of the western portion of the State. The width of this country is roughly about 250 miles, while in length it extends from the New South Wales border on the south half-way up the State northward in a curve bending westward to near Cloncurry. The chief centres of production have been Kynuna, near Winton, Opalton and Fermoy in the Longreach district, Eromanga, and Yowah near Thargomindah. These centres are 500 miles from the eastern coast.

The deposits of precious opal, according to the records of the Queensland Geological Survey, occur almost entirely in the softer beds underlying the siliceous capping of the Desert Sandstone series, but sometimes very beautiful specimens are found in nodules of ironstone embedded in sandstone or clay, these latter being known as "boulder" opal. While in the Desert Sandstone there is everywhere a tendency to opalization and to the common forms such as wood opal and semi-opal, precious opal is found only here and there in small patches. The opal-bearing stratum in which the "sandstone" opal is found occurs at the base of the sandstone at its junction with the underlying clay. Although occasionally found on the surface, being set free by the denudation of the rock in which it was formed, it is generally got some distance below. A common depth of the workings is about 25 ft., but the average is below that, while the extreme depth is 60 ft. or thereabouts. As a rule there are few or no surface indications as a guide to the prospector, and consequently the search for the opal is an uncertain occupation, sites for shafts often being chosen haphazard near where some scattered specimens, or "colours", may have been previously found on the surface. For more detailed information the reader should consult a pamphlet published by the Survey, by C. F. V. Jackson, Assistant Government Geologist, entitled "The Opal Mining Industry and the Distribution of Opal Deposits in Queensland."

In the mining operations, the sandstone generally being soft, only the pick and shovel are required to work it. Blasting, as it is apt to crack the gems, is seldom practised. In the past the favourite kind of bucket and rope used for hoisting the material with the aid of a windlass was made of "green hide" taken from the bullocks killed for home consumption on the local pastoral stations. The opal miner's implements of trade are, therefore, few and light, but men starting out on a prospecting tour have to carry with them a considerable quantity of stores and sometimes a supply of water, necessitating the use of either pack-horses or drays and horses.

The opals of western Queensland, like those of the adjoining State of New South Wales, are unsurpassed for their brilliance and iridescence, and are unquestionably the best in the world. Mr. Dunstan, in describing them, says they make absolutely perfect gems of their class, having the most beautiful tints and an endless variety of colour arrangement, or "fire" as it is called. He adds: "Many pieces as large as a man's head have been found, and one specimen when discovered is said to have been an unbroken piece 5 ft. long. In such large specimens much of the opal is valueless, only the centre and core being good. Pieces of precious opal the size of a man's hand are not uncommon, but they always fractured and mixed with common opal and matrix opal, and are only fit to cut up into small gems. A perfect gem as large as a pigeon's egg is a rarity. Recently a market has been created for the brownish-black ironstone matrix containing veinlets of fire opal. This is sometimes called black opal, but is more correctly termed 'matrix opal.' Some specimens are very pretty when polished, and bring prices almost as high as those of the precious opal itself. Black opal is also a beautiful gemstone, the play of bright purples, blues, greens, and reds, alternating with black, being very attractive in good specimens. It is found near Hungerford, close to the southern boundary of Queensland, and is known as 'Lightning Ridge opal,' Lightning Ridge being the name of the noted opal field of New South Wales."

The cutting and polishing of first-class opal has been carried on in Brisbane, Sydney, and Melbourne, as well as in London, but before the war low-grade opal was sent to Germany to be fashioned.

The theory that the west-central part of Queensland has at one time been part of the ocean is supported by the fact that in the opal mines, besides saurian bones, specimens of opalized sharks' teeth, fish scales, and shells have been occasionally found.

As with sapphires, the official record of opal production is undoubtedly incomplete. Men working, mostly in parties of only two, in these remote regions have not troubled to let it be known what they found. Many, when they got any luck, often made for the nearest bush "pub" where the landlord secured their finds at any price he liked to offer, and the unfortunate finder "knocked down" the proceeds in drink. A company formed some years ago for opal mining did all right as long as they had one responsible man in each claim who held a substantial interest in the company, but when it came to putting men at work simply on wages the opal that had been plentiful before mysteriously ceased to materialize as far as the company was concerned.

The first discovery of opal in Queensland was made in 1872, but it was eighteen years afterwards before there was any official record of production, the first year's output being then valued at £3,000. It rose to £33,000 in 1895, but a few years later dropped to £7,000, and prior to the outbreak of the war was down to £3,000. Then, there being no sale for the gems, practically nothing was done, and since the war ceased the output has been only £500 or £600 per annum. The total to date is a little over £180,000.

One reason why there has been no revival in the industry since the close of the war is that wages on the pastoral stations have been so high that men prefer to work there, with the regularity and comfort attaching to the life, to the arduous and uncertain occupation of opal mining. A very large proportion of the opal in the past has been found, not by practised miners, but by bushmen when forced out of work on the pastoral stations. The vast plains of the western opal country, where there are no rivers, are very arid and subject to long droughts, alternating with splendid seasons from the point of view of the "squatter." When seasons are good there are plenty of work and good wages for the men on the stations, and in a dry period there is no water for the opal prospector or grass for his horse. Unquestionably there is still untold quantities of precious opal to be got over the wide expanse of opal-bearing country of the State, but if this country is to be properly exploited it will have to be done on a systematic scale. Especially water will have to be provided, either by dams or artesian bores, at the principal centres, and probably the Government will be looked to for carrying out this necessary undertaking. Then, both prospecting and mining should be under the direction of experienced miners. In mining especially much wasted effort of the past could be avoided under efficient direction. Given proper facilities for exploitation, the potentialities of the opal-mining industry of Queensland are almost unlimited.

Ontario Silver Mines.—During 1921 the chief producers of silver at Cobalt, Ontario, were: Nipissing, 3,012,614 oz.; O'Brien, 1,408,890 oz.; Coniagas, 1,301,860 oz. Mining Corporation of Canada, 896,627 oz.; La Rose, 658,423 oz. The Keeley, at South Lorrain, produced 281,659 oz.; the Miller Lake-O'Brien, at Gowganda, 223,468 oz.

TELLURIUM

A newly discovered property destined to give the metal a high commercial value

By W. E. SIMPSON, M.Inst.M.M.

Some fifteen or twenty years ago, when the gold mines of Kalgoorlie, West Australia, were at the zenith of their prosperity and all the initial difficulties of metallurgical treatment of the ores had been successfully overcome, a handsome reward was offered by one of the wealthier operating companies for the discovery of any practicable means of turning the tellurium, with which the gold was generally associated, to some profitable commercial account. Extensive investigation followed, but, unfortunately, nothing of economic importance resulted, and although the offer continued open for years, the reward remained consistently unclaimed. No recovery of the metal, therefore, has ever been seriously attempted on the Kalgoorlie field, and the practice continues whereby, as an undesirable constituent of the ore, it is either eliminated by volatilization in the roasting furnaces or run to waste with the residues from the mills.

Even in the most recently published, or 1921, edition of *The Mineral Industry*, the statement is reiterated that " although efforts to discover new uses for tellurium have been made by the Government in co-operation with metal refineries, which have accumulated large stocks, no important commercial applications have yet been developed."

In recent years calls for extensive research have been made in many new directions, arising from the industrial application and development of inventions, notable among which can be mentioned that type of engine best exemplified in the automobile. Starting originally as a heavy stationary appliance, rigidly fixed to a solid concrete foundation, and constructed sufficiently strong to withstand the violence of the shock resulting from the ignition of an explosive mixture of coal gas and air, the internal combustion engine has been gradually improved and modified in the direction of lightness of construction and mobility of action, with petrol as the portable source of power, until, though the various stages in the development, first self-propelled vehicles appeared with facilities for rapidly travelling from place to place, until finally the aeroplane has resulted, which, at present, must be considered as the most advanced type of mechanical product, capable, as it is, of ascending to great heights and negotiating continuous distances limited only in their mileage by the carrying capacity available for the supplies to be consumed on the trip.

A great disadvantage in the existing form of internal combustion engine, however, lies in the inefficiency of its conversion of the freshly generated power into mechanical motion and generally in the lack of elasticity and flexibility so favourably associated with the use of steam. In non-technical language, the disadvantage of the petrol-engine is that it develops its energy with explosive suddenness, the piston being, as it were, hit a sharp blow to impart the required motion, whereas the steam engine has the superiority of being a machine in which the power is under complete control and can be applied expansively or continuously at maximum pressure for such distance in the piston-stroke as, from the point of view of working economy, may be preferred. Thus it is that steam possesses a most desirable quality which research operators have long been wishful to impart to the use of petrol.

For some time past an active campaign of experimental work in this direction has been in progress in the laboratories of many of the automobile organizations, as well as in several universities in the United States, and many useful discoveries have been made. Chief among these is one developed and patented by Thomas Midgley and T. A. Boyd, chemists in charge of the research work in the laboratories of the General Motors Corporation in Moraine City, near Dayton, Ohio, for the use of di-ethyl telluride, a highly volatile compound which, when added in the minutest quantities to petrol for automotive operation, serves to increase the running efficiency of the engine by as much as 100%. What is the precise influence of the contaminant on the petrol no one is definitely able to say. No doubt it is catalytic, and, as with oil in the flotation process, may involve the application of certain principles in physical chemistry. Its action in raising the engine efficiency seems to be that of retarding the " peak " of intensity or maximum of violence in the explosion until such time after ignition as will allow the piston, in its journey through the cylinder to attain a determinable speed. In this way it somewhat resembles the influence of the " propellant " on the charge for certain artillery shells which provides initial motion and permits of the chief part of the explosion taking place with the maximum of effectiveness when the missile has attained considerable velocity in its passage through the gun.

In a demonstration which Mr. Boyd was kind enough recently to give me personally in Moraine City, an automobile engine, retained for such experimental work, was put into commission, and its action so regulated as to give a gradually increasing degree of working efficiency but accompanied, unfortunately, with an ever-increasing degree of discomfort to all associated with the test. First it was operated after the manner of a high-priced smooth-running automobile, which under ordinary conditions gives a travelling efficiency of perhaps only 4 or 5 miles per gallon of petrol consumed. Then the point of ignition was steadily advanced to give a rise in efficiency such as can be obtained in the well-known type of cheap but serviceable car negotiating a distance of perhaps 18 miles to the gallon. Raising the efficiency still further, a point was reached when the shaking, rattling, "knocking," and occasional "back-firing" were such as, apart from all other considerations, would soon have driven any operator to a physical state of distraction and despair. At this stage Mr. Boyd dipped a rag into a highly volatile solution of di-ethyl telluride and held it just sufficiently near the air inlet as to permit of the smallest possible amount of the vapour to enter the machine. Instantly the "knocking" ceased, and the engine functioned with a running smoothness that was truly remarkable, while the quantity of petrol being consumed was reduced to about one-half its former flow. The amount of the telluride added to the petrol was almost infinitesimal—one part to about ten thousand—and it is easily demonstrable that with this contaminant the mileage per gallon will be increased by 100%, high-compression engines of necessity giving the best results.

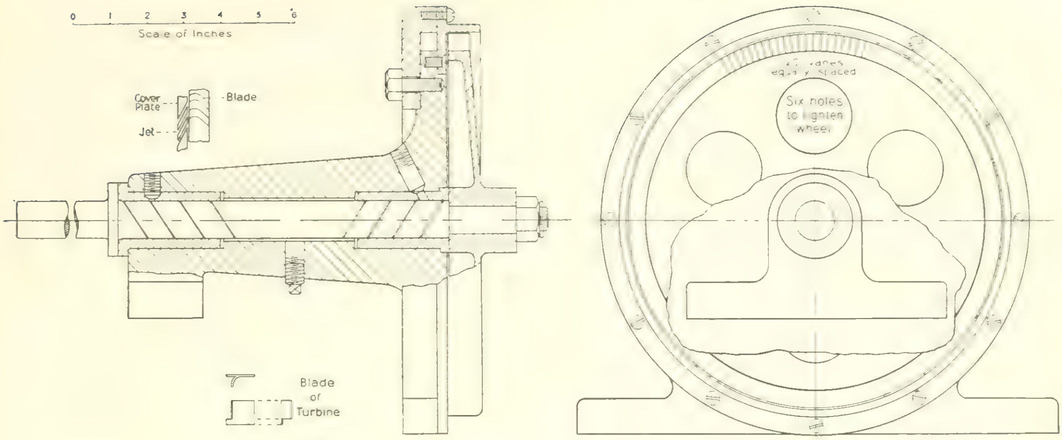
Two factors, however, militate against the commercial use of the telluride. One is the scarcity of the metal, as some 1,500 tons annually would be needed to satisfy the anticipated demand, while only 60 tons per year are available. The other is that the odour of the compound is most obnoxious, and that the exhaust gases are extremely poisonous. Possibly the earliest commercial application will be in the running of aeroplanes, where obnoxious fumes will trouble no one, and speed, the matter of chief consideration, will permit of 300 miles per hour being well within the limits of practicability. Crossing the Atlantic may, therefore, at no very distant date, present no more difficulties than crossing the Channel to-day, and for this purpose who knows but that the essential auxiliary, tellurium, which till now has been absolutely valueless, may shortly become of almost priceless worth.

AN AIR-DRIVEN FAN

By MAURICE GREGORY, A.M.I.E.E., Assoc. Inst. M.M.

The interesting and instructive article in the February and March issues of the MAGAZINE on mine fans by Mr. Penman, and especially that part dealing with the "Typhoon Booster," recalls a small fan on a somewhat similar principle which the writer designed and put into operation in a gold mine in a level 1,300 metres long, where there was no natural draught and consequently the result of blasting operations seriously hampered subsequent work in the vicinity for several hours. The air-jets which were previously installed were found to be quite ineffective as a means of air-propulsion, and only created a local disturbance.

The arrangement consisted of a small turbine driven by compressed air. On the end of the shaft a runner was secured and enshrouded in a volute. The fan and turbine were fixed conveniently on one side of the level about half-way along, and the discharge of the fan and exhaust of the turbine passed through a timber brattice, across the level, which was fitted with the usual door to allow passage of ore cars, etc. The turbine wheel was of the lightest construction, and 9 in. diameter. On the periphery were secured 120 blades of special shape made in a former to secure uniformity. At right angles to the blades holes were drilled in a brass ring forming the cover of an annular space in the turbine body. The holes were sixty-one in number, equally spaced, and 0·05 in. diameter; they formed the jets which impinged on the curved side of the blades. The shaft was of special design with regard to oiling grooves; these are arranged so that the oil is drawn away from the bearings, which are fed from a tank towards the centre, a pipe thence



GREGORY'S AIR-DRIVEN VENTILATING FAN.

returning it to the tank, and thus securing a circulation.

The fan runner was 8 in. outside diameter, and consisted of two light brass rings set $3\frac{1}{2}$ in. apart within; between these, and set radially, were the blades. Their number was thirty-two, and they were $\frac{5}{8}$ in. deep and $\frac{1}{16}$ in. thick, being simply straight strips of sheet iron bent at right angles at each end to form ears for attachment to the rings by rivets. The boxing or casing of the fan was a simple volute formed of two pieces of wood 1 in. thick and shrouded with sheet iron nailed to the edges of the wood. The opening was 8 in. by 4 in. at the discharge.

The air-consumption was low considering the advantage gained. The total area of all the ports equalled that of a $\frac{3}{8}$ in. diameter pipe. The air inlet was $\frac{1}{2}$ in., so that there was always a good storage in the annular space preventing wire drawing.

The special advantage claimed is that the air of the level is propelled by the fan and the exhaust from the turbine freshens it. A $\frac{3}{8}$ in. pipe discharging live air into the level would give fresh air only and no propulsive power, whereas in this machine the kinetic energy of the compressed air is converted to propulsive energy and the exhaust freshens the foul air of the level.

The following test is interesting: Air pressure in annular space 30 lb. per sq. in.; air consumption 82·9 cu. ft. free air per minute; air delivered by fan 723 cu. ft. per minute; temperature of level before installation of fan 78° F.; temperature of level after installation of fan 72° F.; size of level, approximately, 6 ft. by 5 ft.

The reason for the fan not being incorporated with the turbine wheel proper was that several of the latter were used for small power purposes about the mine, one of which had an emery wheel mounted and was used for ending up drill-shanks.

LETTERS TO THE EDITOR

Ilorin Pegmatites

The Editor:

SIR—I should like to make some comment on Mr. Whitehead's and Mr. MacLachlan's papers on "The Origin of Primary Ore Deposits in the MAGAZINE for January. I am not acquainted with the Ilorin pegmatites, but it is fairly safe to assume that they do not differ essentially in origin or mode of occurrence from pegmatites in other parts of the world. Pegmatites appear to be the result of crystallization of a strong aqueous, and highly acid fraction of granitic magmas exuded through fissures in the solid upper portion of a cooling batholith. I have observed pegmatites in two different positions with reference to the granite surface: (1) As sheets lying between the periphery of the granite and the base of the overlying sediments, and (2) as dykes. (I prefer, however, to call them veins, for I fail to see any essential difference between them and quartz veins and the two may be seen to merge one into the other.) I have never seen peripheral pegmatite sheets carrying cassiterite, but they frequently contain large quantities of tourmaline and also topaz. They extend in some cases for thousands of feet, and their average thickness is not usually as much as 20 ft. The maximum thickness observed was about 200 ft., which appears to be quite exceptional, and in this case the upper portion of the sheet was composed almost entirely of quartz in radio-crystalline bunches developed from almost equidistant centres and in successive layers.

Sheet pegmatite is usually coarsely crystalline, quartz predominating over its other main components, potash-felspar and muscovite. I have never seen these sheets with similar rock both above and below, as shown in Mr. Whitehead's diagram. This apparent similarity in the nature of the walls leads me to doubt the theory which that section is designed to illustrate. If the gneiss referred to is ortho-gneiss I should be inclined to regard the pegmatite as being in the form of dykes or veins. If the upper is para- and the lower ortho-gneiss the pegmatite might be in sill or sheet form, but, as Mr. MacLachlan contends, the great superficial extent of the pegmatite demanded by the sill hypothesis forms the strongest possible argument against its validity.

The pegmatite sheets to which I refer owe their form probably to the magmatic mother-liquor having found the line of least resistance in raising the sediments above the granite instead of rupturing them. When relief is obtained by fissuring it is obvious that both walls of the dyke or vein will be of similar rock. Mr. Whitehead's sills may possibly be a number of small sheets traversed by veins of pegmatite carrying cassiterite, and, where they pass through the sheets, almost unrecognizable except by local greisenization and mineralization. Quartz veins have been observed traversing aplite dykes in phyllite, both the aplite and quartz carrying wolfram. At the intersection the aplite was greisenized, the quartz contained mica, and its walls were ill-defined.

The occurrence, even sporadically, of cassiterite in the pegmatite combined with the fact that it is bounded on both sides by similar rock, leads me to favour Mr. MacLachlan's rather than Mr. Whitehead's theory.

The quotation from my paper on p. 29 refers to the solidification of the primeval crust and the probable rapid dispersal of ores deposited at that time. If Mr. Whitehead regards the Ilorin gneiss as a "vestige of the molten globe," the absence of ore minerals other than cassiterite is hardly in accord with what we should reasonably expect.

I state that tourmaline and topaz both alter to mica, but do not suggest that the mica associated with cassiterite had that origin. Similarity of molecular structure often indicates similar mode of origin of silicates, and it was in this connexion only that I applied the statement. Greisenization results in potash-felspars being generally converted into muscovite, and that this process is connected with mineralization admits of little doubt. This is borne out by the infrequency with which felspars occur in veins in association with high-temperature ores.

I venture to think that Mr. Whitehead may not have attached sufficient importance to his own suggestion that the cassiterite may possibly favour "the shear planes." If this is so, it is probably of later origin than the pegmatite, which would completely alter the nature of the problem.

My views regarding certain aspects of ore deposition in general and as to the mode in which tin is transported and cassiterite is deposited have undergone modification since 1920.

The thanks of your readers are due to Mr. Whitehead for having drawn attention to a very interesting problem.

J. Morrow Campbell.

Rangoon. *February* 17.

Gold and Currency

The Editor:

Sir—The relationship of gold to currency is one of the many urgent issues now confronting the world. Its claim to prompt consideration are the stronger, and failure to give it such is the more inexcusable, because it is a matter that is capable of being dealt with effectively by Government action; unlike many of the pressing problems, whose solution depend on factors outside the control of any authority or authorities.

That the present widespread paralysis of industry is due largely to the dislocation in international trading is certain. That the said dislocation is largely due to the fact that the European nations have at present no common medium of exchange is equally certain. It can easily be demonstrated that the only feasible way to re-establish a common medium of exchange is to re-establish the interchangeability of gold with paper money in the countries concerned. The British Empire is more deeply concerned in this than others, because of its enormous international trade; also because the partial disuse of gold for purposes of currency has removed a large part of the market for gold. This has decreased the market value of gold relatively to other commodities.

The said decrease has had and is having its natural consequence: a great decline in gold production and an even greater decline in the profits thereof. The British Empire, being the possessor of 70% of the world's gold producers, is thus caused a heavy loss. The authority that can deal with this issue is the British Government. If it took steps to act, the Governments of Australasia and South Africa would certainly fall into line. It is to their interest as large gold producers to do so.

It is indeed amazing that the British Government has, so far as is known, given no consideration to this subject. It is even more remarkable that the big gold mining interests centred in London have not made an earnest endeavour to induce it to do so. Those interests are sufficiently powerful to command a hearing. They are wealthy enough to have instituted a campaign of education and propaganda, and it would have paid them more than handsomely to do it.

The disappearance of gold as currency has been accompanied by the inflation of the currency. The inflation has made it impracticable to maintain its interchangeability with paper money. The cure is practicable only in two ways: (1) to decrease the paper currency to a degree permitting of its being again interchangeable with gold; (2) to increase the standard price of gold to a like degree.

To increase the quantity of gold sufficiently for the purpose is not practicable. It would require a huge addition to existing stocks. Direct subsidies to gold production would increase output, but would leave the matter of total stocks but slightly affected. Subsidies would check the decrease in production. They would not enable interchangeability to be re-established.

(1) It appears that certain interests are trying to decrease paper money to the extent necessary. It is difficult to see how the attempt can succeed. One great obstacle exists in the huge national debts. The great bulk of these were incurred during the period of great inflation. To deflate the paper currency (and therefore prices) while these loans remain unpaid, would be to increase the real value of the said loans to the extent of the deflation.

It may be taken that the proportion of gold to paper that would enable interchangeability to be re-established, is about that existing prior to the war. The paper issues were then as large relatively to gold as long experience had indicated to be safe.

The interest on the British national debt is now about £400,000,000. That on the Australasian debt is some £40,000,000. It seems impossible that, on the pre-war basis of money values, those countries would, or could, pay such amounts in addition to the already hugely swollen national expenditures. Still more impossible does it seem that they could do this and redeem the said debts at the increased real values. The burden would be intolerable and insupportable. It appears, indeed, that, were these countries to find themselves on a basis of pre-war prices, their Governments would find that their shrunken revenues (shrunken in nominal or money values) were totally insufficient for their needs. They would be faced with the necessity of either inflating their currencies (prices) or of repudiating a large proportion of their indebtedness.

If the attempt at deflation succeeded, then the result would be a gross injustice. It would saddle the communities and hosts of individuals with burdens of debt far in excess of what they borrowed. That the people would sooner or later recognize this and repudiate the action can hardly be doubted.

Again, the evils of a period of deflation are great. They are bad even when the deflation is unpremeditated and not recognized. The dislocation of industry and trade is great. The evils would be greatly accentuated when it was perceived that a period of deflation was being definitely engineered.

People would fear to produce and to purchase, knowing that before selling prices would fall. The world has suffered much from the evil effects of deflation since 1919. Much of that deflation was natural and unavoidable. But that we should now be subjected to a deliberate period of deflation, with continued disastrous results, is unjustifiable and intolerable.

The inflation caused by war conditions undoubtedly inflicted hardship on pre-war creditors, and especially on pre-war Government bond holders. That hardship, however, was inflicted years ago. Most of the creditor class have done extremely well during the inflation period. The present holders of pre-war Government bonds will be largely others than those who held them in 1914.

Many of the present holders doubtlessly bought them since the inflation. Anyhow, the contention that enormous loans, both national and individual, should be greatly increased in order to rectify a past injustice done years ago to lenders of sums of one-tenth of the first-named loans is illogical and impracticable. The case for re-establishing interchangeability through deflation fails on every ground.

(2) To increase the price of gold to an extent that will enable its interchangeability to be re-established is the practicable and logical way of effecting the object. The procedure would presumably take the form of retaining the present nominal currency unit—the sovereign—and putting into it the amount of gold that will meet the circumstances. The amount would be the work of a properly constituted body to decide. The bases would be the present quantity of paper money in circulation and the amount of gold that is estimated as representing Britain's normal proportion of the total available supplies. Presumably the latter would be approximately the amount of gold represented by Britain's gold coins prior to 1914. As a number of important countries are still on a paper basis, the amount might be somewhat larger than then.

It is probable that a decrease in the gold contents of the sovereign of about one-third would meet the case; that is, an ounce of gold would make six sovereigns or something over.

America has re-established interchangeability, and on the pre-war relationship of gold and paper. She has been able to do this for two reasons: (*a*) Her inflation was far less than Britain's; (*b*) the European countries and the Empire having ceased to use gold as currency, she has secured gold more cheaply than otherwise would have been the case.

There are, of course, factors to be considered. The Empire's re-establishing gold as currency would increase the demand and therefore the market value. This factor would need to be allowed for in determining the new price (the amount to put in the sovereign).

If other countries re-established the gold basis, the demand for gold would further increase; its market value would rise; there would be deflation in prices. The ideal, therefore, would be that all the countries now using paper only should re-establish interchangeability at the same time. In view of recent vagaries regarding their currencies, this does not seem probable. It is, then, for Britain to act. If any others will do simultaneously, so much the better. The writer does not know what gold Britain has stored in her banks. Presumably it is insufficient to enable her to re-establish interchangeability, and she would have to absorb from outside. To the extent of the latter process the effect would be to increase the real value of gold and so to deflate prices in the same ratio wherever gold is an actual medium of exchange. This effect would be greater if other nations also needed outside gold for the same purpose.

The advantages of Britain so acting are briefly as follows: Her price level and currency would be definitely stabilized with regard to America and all the countries now using gold. Trade with those countries would thereby be facilitated. Her domestic price level would be stabilized, with resultant steadying of wages and other costs of production, etc. The Empire, joining with America and other countries in possessing a gold basis, would create an added inducement for other countries to do likewise. Her example alone would have a great effect. Other nations would see the advantage, and probably the practicableness, of following suit. The production of gold would become more profitable and would expand, to the benefit of one of the Empire's great industries. If not done the decline in that industry will continue.

Perhaps the chief obstacle to the reform is the fact that the power to effect it rests in the hands of politicians, not of economists. In such a matter as this they would probably be guided by the advice of bankers. The bankers do not consider themselves as entrusted with the national welfare, except in so far as it affects banking interests. At the present the indications are that bankers believe that their interests are best served by a policy of deflation, and so it seems that their influence would be against reversion to a gold standard based on present price level (on an increased price for gold).

A wider vision would indicate that banking interests would gain more by stabilizing industrial and financial conditions than by attempts at a deflation which must have highly detrimental effects and may possibly lead to such public loss and discontent as to create a serious menace to all capital.

There is another theoretically possible method of Britain becoming able to re-establish the interchangeability on present face values. It is that she should, relatively to other nations, increase her production of wealth and her trade to such an extent that, provided she does not further inflate her currency, the purchasing power of her paper will increase to the extent necessary for the purpose. There is not the slightest indication of such a thing happening. It is so improbable that it can be ignored, as being practically impossible.

Another idea is that the Government should lend itself to a deflation of currency and of prices to the extent of reversion to the gold standard on the pre-war basis and declare its national loans, so far as its own nationals are concerned, to be reduced in the estimated proportion—say, to two-thirds of the amount borrowed. This would have the same effect as the scheme propounded herein, so far as the national debts and so far as gold producing is concerned. As regards the debts, incurred during the period of inflation, the action would be just, though the action would constitute a nominal partial repudiation, but not a real one.

There would, however, still be the question of private debts. The writer not knowing on what basis debts to foreign countries were incurred, can offer no comment on these.

If this idea were applied all round, the effect would be practically the same, as regards all existing liabilities and existing values, as that of increasing the money value (price) of gold. Everyone's assets and liabilities would become worth less nominally, but not really.

It, however, would necessitate a proportionate repricing of all wages, commodities, etc. It would mean a sudden deflation of everything. If it be possible to effect, the injury to industry would probably be less than the effects of a gradual deflation. Psychology would play an important, perhaps a dominant, part in determining this. It would, anyhow, be just in principle.

It is for everyone to decide for himself what the probable effects would be. The writer believes they would be far worse than those of, and the idea more improbable of realization than, the revaluation of gold. It is simpler and better to bring gold into line with present price-level than to force the price-level into line with the present mint value of gold.

It is difficult to see why the gold mining interests, which are the ones specially injured by the removal of gold from use as circulating currency, should not place this issue before the Government.

H. R. SLEEMAN.

Perth, W.A., *January* 18.

BOOK REVIEWS

☞Copies of the books, etc., mentioned under the heading "Book Reviews" can be obtained through the Technical Bookshop of *The Mining Magazine*, 724, Salisbury House, London Wall, London, E.C.2.

The Elements of Fractional Distillation. By C. S. ROBINSON. Cloth, octavo, 204 pages, illustrated. Price 12s. 6d. New York and London: The McGraw-Hill Book Co.

It is a curious, though probably fortunate, coincidence that this volume makes its appearance almost at the same time as a much larger text-book on "Distillation Principles and Processes", published by Macmillan, and written by Dr. Sydney Young, one of the recognized authorities on the subject, whose "Fractional Distillation," published in 1903, is well known to every advanced student and worker in organic chemistry. The present author comments upon the fact that Young's original book had a decided laboratory aspect, and lacked practical application to large-scale commercial processes; he seeks therefore in the "Elements of Fractional Distillation" to enlarge the scope of the subject, by enunciating the principles involved and their wider application in the arts, in order that engineers and other technical operators may have a sound theoretical basis to work on. He further proposes to follow this book with another, dealing with the general practice of fractional distillation and its application to the several industries, aspects treated by Young and his six collaborators very fully in the new work above mentioned.

When circumstances ordain the simultaneous publication of two works on the same subject, it becomes the province of the reviewer to differentiate them to the extent of pointing out their respective merits, more particularly those aspects of the subject treated by one, though omitted by the other. A cursory examination of the present volume might easily convey the impression that considerable overlapping occurs between the two works, but careful analysis of both soon reveals that this is not the case, the respective authors viewing the subject from quite different standpoints.

Professor Robinson's book claims our attention largely as an exposition of those physical-chemical principles apposite to the study of distillation processes, such principles involving chiefly the phase rule, with one, two, and three component systems, gas laws, and theories of solution. This qualitative aspect of the subject is only incidentally touched upon by Young, and to this extent the present volume is quite unique. The quantitative elements are illustrated by the author by four chapters on distillation, one of which is concerned with the rate of fractionation, giving details of some hitherto unpublished work by W. K. Lewis. There follow some chapters on the design of distilling equipment, embodying descriptions of the continuous still, fractioning column, condenser, and accessories. In this section there is a certain amount of unavoidable overlapping between the two works, but the author is careful to keep the principles involved well in the foreground, rather than present a mass of practical facts and manipulations. On the other hand, Young goes into considerably greater detail in connexion with design and types of apparatus, though his remarks on continuous distillation and stills for three component mixtures are by no means so comprehensive as in the present book.

The author discusses certain types of apparatus in use, with special reference to the manufacture of ammonia, benzolized wash-oil, and methyl and ethyl alcohols. This part of the book, though of limited value, is good, not so much for practical details as for the principles involved in the employment of the requisite stills. A lengthy appendix completes the volume, including vapour-pressure curves for common liquids, vapour pressure data, boiling point relations for various binary mixtures, etc., also a bibliography.

We have little hesitation in recommending the purchase of this book by those interested in the study of distillation, whether as a commercial or academic pursuit, and whether they possess the new "Young" or not. The one is distinctly supplementary to the other, and the most composite knowledge of a complex branch of chemical science is gained by frequent reference to both. The harmonious balancing of theory and practice, as evidenced by the publication of these two works, is not always achieved in applied science, to its decided detriment.

H. B. Milner.

Petroleum in the Punjab and North-West Frontier Province. By E. H. Pascoe, M.A., D.Sc. Mem. Geol. Sur. India, vol. xl, part 3. Calcutta, 1920. Price 5rs.

The fortieth volume of the Memoirs of the Geological Survey of India has been one of the most instructive contributions to the economic development of that country yet published. It has been issued in three parts, the first in 1912 dealing with the oilfields of Burma, the second in 1914 with the petroleum occurrences of Assam and Bengal, and the third in 1920 (here under review), embracing the oil occurrences in the Punjab and North-West Frontier Province. The work is largely the result of field researches carried out by Dr. E. H. Pascoe, officiating director of the Indian Geological Survey.

The petroliferous region here described occupies a broad belt of country flanking the Himalayas, stretching from Simla to Rawalpindi (though ill-defined between these two places), thence westwards for about 140 miles across the Indus into Kohat and Bannu, and southwards into Baluchistan; it can be traced round the Mekran coast and ultimately to the Persian Gulf, where it continues as the well-known Persian and Mesopotamian belt. In the Punjab and North-West Frontier region, the belt lies between two distinct systems of tectonic movement, occupying the re-entrant formed by the Himalayas to the east, with their N.W.–S.E. trend, and the Afghanistan-Baluchistan system to the west, the latter involving a complicated series of structural elements having a curving, north-to-west, strike, and designated as the Attock arc.

A striking analogy is afforded by the coincidence of this belt in North-West India with an ancient river course (Indobrahm), and the petroliferous belts of Assam and Burma, likewise coincident with Tertiary river courses; the significance of this is obvious when the nature of the deposits and the modes of origin and occurrence of the oil are compared in all three regions.

The Punjab belt is geologically divisible into two roughly concentric halves, a northern and a southern, separated by a synclinal area through which the Soan (the relic of the ancient Indobrahm River alluded to) makes its way westwards to the Indus. The northern portion of the belt embraces the oil occurrences of Rawalpindi, the Kala Chitta Hills, Khaur, and the Trans-Indus salt area. The southern part includes the indications in the Salt Range and in the Khasor Hills.

The local structures are principally anticlinal, somewhat complex, but usually conforming in trend to the strike of the main tectonic features developed. The rocks involved, in which the petroleum or gas occur, belong to both the Murree and Nummulitic Series (Miocene and Eocene respectively), the former being absent in the south, but strongly developed to the east and west of Rawalpindi. The oil would seem to be indigenous to the Nummulitic series, its appearance in the Murree beds being due to upward migration; its origin the author regards as doubtful.

The knowledge of the occurrence of petroleum in this region is by no means new, exploitation having been carried on intermittently since the middle of last century. Very little success has followed operations, however, the most promising enterprise being that of the Attock Oil Co., which has carried out developments at Khaur, where wells have yielded oil of gravity varying with depth. From the upper sands the heaviest oil is obtained, s.g. 0·934; down to 500 ft. the gravity fluctuates from 0·894 to 0·876, while in deep sands it ranges from 0·877 to 0·840. The oil is generally darker coloured than that of Burma, and on the whole is not so viscous. Up to November, 1917, the total production amounted to 750,000 gallons.

H. B. Milner.

Oil Encyclopedia. By Marcel Mitzakis. Cloth, octavo, 551 pages. Price 21s. net. London: Chapman & Hall, Ltd.

One might almost describe this book as a card-index to the petroleum industry, not only on account of its systematic arrangement, but also because of its convenience as a source of reference to the many and varied matters pertaining to oil. It contains information hitherto scattered through a large technical and non-technical literature, and embraces not only explanations of terms commonly employed in oil parlance, but also gives details of chemical, engineering, geological, geographical, and biographical interest, though not always with that degree of accuracy to be expected in a work of this nature.

In the first place the book lacks completeness, a criticism which any compilation of this character invites, more especially when the subject concerned is as ramified as in the present case; in extenuation, however, it must be admitted that an oil encyclopedia, to be exhaustive, would fill several volumes, each double the size of this publication, and would therefore be considerably more expensive and possibly of less general utility. Notwithstanding this, we are quite at a loss to understand certain omissions in a book of this nature; for example, the terms bushing, calf-line, collar, hitch-string, shell, shut-off, side-track, and spider are all commonly used by drilling engineers, to mention only a few; again, the geological terms unconformity, terrace, break, strike, dip, lenticularity, correlation, and infiltration (to quote a few at random that often occur in technical reports) are omitted, whereas words such as anticline, syncline, fault, limestone, dolomite, Triassic, and æolian, are given adequate space, if, in some instances, inaccurate definition.

Secondly, we have noted many inaccuracies in description, of which the following are the most important:—æolian is described as a special kind of sand found in oil-bearing strata; since the term connotes desert deposits, or wind-blown detritus in general, it is the very last type of sediment with which oil would be associated. On page 88, a paragraph is devoted to the word Cambrian, since "so many oil strata occur disseminated among Cambrian deposits"; we only know of one instance in the world where this formation yields evidence of petroleum, that being the Potsdam Sandstone, New York, which would be more accurately described as a gas-sand; the cases mentioned by the author have no commercial significance whatever. The division of the Cretaceous system into Upper Cretaceous and Neocomian (p. 120) is somewhat incongruous, while it is certainly news to be told that the Portland Sand is petroliferous in this country, providing it is involved in suitable geological structures (p. 167). On this same page and again under Heathfield on p. 234, some erroneous data are given with regard to the natural gas resources and exploitation; there are certainly not twenty producing wells, nor is the village of Heathfield being supplied with gas for domestic purposes at the present time. The station bore-hole is the only one giving a reasonable supply, and that supply is used entirely by the railway authorities. There are certainly not large supplies of gas available, and neither is there any reason "to warrant the sinking of many scores of wells." Torbanite is described as a peculiar kind of shale, which occurs in New South Wales, Australia; although Torbane is subsequently mentioned, the definition is misleading.

Probably the most complete, hence the most valuable part of the book, is that dealing with place-names; the author has certainly given us a useful gazetteer in this respect, many of the little-known oil districts being mentioned. In the case of some of the larger oilfields, attempts have been made to summarize both the geology and economics, but with little success; with the space available, the task, especially in the former connexion, was far too ambitious, and short references to individual authorities would have been more effective. While the summaries of the Egyptian and some of the European fields are good, the information given with regard to many of the American fields is very poor, and by no means lucid, even as a resumé.

We suggest that in future editions of the work more space be devoted to technical terms used in oilfield development, especially in connexion with drilling, which may be said to have a language of its own; this could be done if necessary at the expense of definitions of some of the rarer hydrocarbon compounds, on p. 483 and elsewhere. A complete dictionary, rather than an incomplete encyclopedia, of petroleum is what is badly needed by the average non-technical reader to-day.

H. B. Milner.

An Introduction to the Study of Metallography and Macrography. By Léon Guillet and Albert Portevin. Translated by Leonard Taverner, A.R.S.M., D.I.C., with an introduction by Professor H. C. H. Carpenter, F.R.S., of the Royal School of Mines. Cloth, octavo, 289 pages and 97 plates. Price 30s. net. London: G. Bell & Sons, Ltd.

This work is an important contribution to the bibliography of metallography, as it deals in a very clear manner with the more practical aspects of the subject. On this account it may be thoroughly recommended to all who have dealings with metals and who have to investigate their failures in service. The book is remarkable for its clear style, excellent illustrations, and admirable choice of subject matter. It is based on the course of instruction given by the authors at the École Centrale des Arts et Manufactures, and is therefore useful both as a handbook and as a work of reference. The book is, as the authors state, an introduction to the study of metallography, and the endeavour has been to state principles and to illustrate them by means of the most typical industrial examples. Frequent references are given to enable the reader to consult works for further information, not indicated in the present volume.

The last three chapters are devoted to the "macrography" of metals and alloys, which enables the investigator to determine the arrangement and general distribution of the constituents. This important subject is generally considered to be a branch of metallography, although the authors prefer to treat it as a separate science. Until lately it has almost exclusively been applied to the study of steels, but it is now employed in the study of other alloys, and the conclusions to be drawn from macrographic examinations may be easily generalized. In the case of non-ferrous alloys, this form of investigation has been of the greatest use in revealing the causes of failures, especially in "extrusion" work. Ferrous macrography was utilized by Roberts-Austen for investigating the properties of steel rails, and the results he obtained were published in the Fifth Report to the Alloys Research Committee in 1899. In the following year more work of this character was completed, and was published in a report of the Committee appointed by the Board of Trade to inquire into "The Loss of Strength in Steel Rails through Use on Railways." During the Great War much use was made of this science by various Government departments, especially the Air Ministry, and it was particularly useful in investigating aero-engine parts, such as crank-shafts, and in revealing hair-cracks in nickel-chrome steels induced by temper brittleness.

The outfit necessary for macrographic investigations is small. The cutting of sections can be done in any machine shop, and for the polishing of them no special plant is necessary, the finer surfacing being produced by rubbing down on emery papers of varying grades. The etching is generally done in one of three ways: (1) By immersing the specimen in the reagent and occasionally washing it under a tap to remove any adherent deposit; (2) by rapid etching by painting on the reagent with a brush; and (3) acting on the polished surface with an acid when sulphides and phosphides of iron decompose evolving H_2S and PH_3, which are allowed to discolour a sensitized surface such as bromide paper. Much useful information can be obtained by this simple means even without a large amount of previous experience; polishing alone will reveal blow-holes, slag patches, and cracks, while subsequent etching will show whether the material is homogeneous or not. The so-called "sulphide prints" obtained in (3) are useful in indicating the distribution of sulphur and phosphorus in iron and steel.

The study of the microstructure is not so simple as the foregoing, as it entails a certain amount of application and experience. However, the authors place the subject before the reader in so lucid a manner that it is easy to follow. Metallography consists in the examination of a polished and etched surface of a metal by reflected light under the microscope, and the authors rightly divide the examination into four principal operations: (1) Selection of the specimen; (2) polishing; (3) etching; and (4) microscopical examination and photographic record when required.

The portion of the work, dealing with this branch of the subject, is divided into the following chapters: (I) Metallographic Technique, which relates to the apparatus and methods employed in preparing and examining specimens under the microscope. (II) The Theory of Metallography—the constitution of alloys; the relation between the equilibrium diagram, the constitution and the physical properties. (III) The Mechanical Properties and Treatment of Metallurgical Products. (IV) The Industrial Application of Metallography to Iron, Steel, and Ferrous Alloys. (V) Industrial Applications of Metallography to Metals and Alloys other than Iron and Steel.

Hitherto, the miner and the metal-winning metallurgist have not brought the services of metallography and macrography to their aid at all seriously; it is in the Ordnance and aircraft factories where these sciences are continually being brought to bear on practical problems, such as those connected with armour-plate, guns, aeroplane crank-shafts, etc. However, there are many troubles continually occurring to plant and machinery on mines and metallurgical works where the microscope or even a macrographic examination would be invaluable. The petrologist is already half trained for metallographic work, and examinations could often be entrusted to him with advantage. With quite a small outfit it is possible to investigate such as the following: (1) Corrosion effects, (2) defective welding, (3) presence of impurities—including slag, coke, and oxides, (4) valves turned or forged, (5) crank-shafts forged or gapped out, (6) varying size of grain in large castings and state of cohesion, (7) defective heat-treatment, (8) case hardening, (9) hair cracks, and (10) segregation. Many other instances will doubtless occur to the reader in which metallography can be of service.

The work is written with characteristic French clearness of expression, and all operations are explained in minute detail. The book is eminently a practical one, in which principles are outlined and then illustrated by means of important examples; hence, it should appeal to the miner and the metallurgist. The translator, Mr. Leonard Taverner, A.R.S.M., D.I.C., who is himself an expert metallographist, has taken special care to maintain the character of the original French. The book should appeal strongly not only to engineers, but also to those who are commencing the study of the subject, and this work should certainly find a place in every technical library.

W. H. MERRETT.

Metallurgy of Zinc and Cadmium. By H. O. HOFMAN. Cloth, octavo, 341 pages, illustrated. Price 20s. New York and London: McGraw-Hill Book Co.

Professor Hofman's books on general metallurgy, metallurgy of copper, and metallurgy of lead are so well known that a satisfactory reception for this further publication is inevitable. The book consists of about 300 pages devoted to zinc and 30 pages devoted to cadmium, and is illustrated by means of 261 figures. The metallurgy of these metals has made immense progress during recent years, and this treatise, dealing with the subject from a chemical and technical point of view, will be a welcome addition to our bookshelves, especially as it includes a considerable amount of detail obtained during visits to the large American zinc-producing plants. The present strong position of the American zinc producers is evident from a comparison of the statistics which show that, of a world production of 983,540 tons in 1913, America produced 308,540 tons, whereas of a world production of 566,480 tons in 1919, America produced 409,800 tons.

The early chapters deal with the history, properties, uses, and alloys, compounds, and ores, but the major portion is devoted to the calcination, roasting, and smelting of zinc ores. An excellent account is given of the methods and furnaces used for the roasting of blende, which is up to date and illustrated by excellent figures. The manufacture of retorts and condensers is dealt with, and a description is given of charging, discharging, and retort-cleaning machines. Of the smelting methods the Belgian process receives the largest amount of attention, although the Rhenish and Silesian methods are also described.

The electric smelting of zinc ores occupies only four pages, and the author states that the success of the treatment of mixed sulphide ores by roasting and leaching, followed by electro-deposition of zinc and smelting of residue, appears to have put a stop to electric smelting. An excellent account is given of the electrolysis of zinc ores, in which the principles are considered and economic conditions illustrated by a series of curves showing the effects of amounts of acid, temperature, time, etc., on the electrolysis. The sulphating roasting of the ores, lixiviation, purification of solution, and treatment of residues and cathodes are dealt with, and detailed descriptions of the process as carried out at Great Falls, Trail, and Park City are given.

There is less reference in the book to complex lead-zinc sulphide ores than would be expected, but apart from this the subject is treated in a comprehensive manner. The matter is presented in an attractive form and is well illustrated by excellent diagrams.

C. O. Bannister.

NEWS LETTERS

KALGOORLIE, W.A.

March 17.

New Prospecting Methods. — The Prospecting Board, acting in an advisory capacity to the Mines Department, has at last persuaded the Minister for Mines that subsidized prospecting without supervision has proved a failure. A scheme recommended some time ago by the Board is to be tried in a modified form. A prospecting party of ten experienced prospectors under the leadership of one who has a working knowledge of mineralogy, geology, and mapping, is to be equipped by the Department. The leader is to be given sufficient sustenance allowance as well as his share of any finds made, so that a good practical man should be secured. He will choose his party from a number of applicants, who will each receive a sustenance allowance of from £2 to £3 per week, the latter amount for married men. The area of the country chosen for the work has been examined by the Geological Survey and is considered well worth prospecting. An area has been reserved, so that "dingo prospectors" who follow up the party will be unable to participate in any finds made by the party, until the latter has thoroughly tested this area, and applied for any leases the members consider worth taking up. The men will work in pairs, using their own methods of prospecting, but the leader will see that the work is done methodically, and all information obtained will be described and mapped by the leader and filed at the Mines Department. By this means permanent records of such work will, for the first time, be made available for use by other prospectors in future. In addition to this, the great amount of time usually wasted by the whole party coming in to the nearest town for stores and in carting water will be obviated by certain members being deputed to do this, while the others carry on their full time in actual prospecting. It is an interesting experiment, and it is hoped that it will be successful and become the forerunner of a series of expeditions to prospect for new lodes, utilizing the joint knowledge of sound prospectors and mining geologists.

The question of finding a leader for this scheme calls forth a weakness in our mining education that has been felt by mining engineers. Very few men in their training take the trouble to specialize as "ore finders." Graduates, as a rule, lean toward metallurgical chemistry, plant work, and surveying, whereas it is almost impossible to secure a young graduate who will make a study of ore finding. Some of the older men have acquired it as the result of long experience, but frequently they cannot afford the time to do this work and the Schools of Mines so far have been unable to supply men who are willing to learn that branch. The dearth of economic geologists available in this State has necessitated the loan of Mr. Torrington Blatchford, the Assistant State Mining Engineer, to the Freney Oil Company, to take charge of prospecting work in the Kimberley area.

Other companies are ready to start work but cannot find trained men with sufficient geological experience to take charge of the parties. Yet if a metallurgical chemist were required there would be dozens of applicants.

HAMPTON PLAINS.—The Celebration Company's treatment plant is complete, and the machinery is being given a trial run. Experiments showed that an all-sliming process is needed for this ore. The ore will be crushed in a 10-stamp mill, any coarse gold amalgamated in a grinding pan, the pulp then pumped to a cone classifier, underflow to a tube-mill, while the overflow goes direct to a thickener and on through a counter-current decantation plant. All the power, including that for winding and air-compression, is supplied by means of suction-gas engines. This is the first producing mine of any size in West Australia that has not any steam power. The ore is easily milled, and there is every reason to believe that the extraction and cost will be very satisfactory.

Now that the excitement over Hampton Plains has died down, the geology of the Celebration line of lode is much better understood. The result of this work, for which especial credit must be given to Mr. Gordon McKern, the geologist of the Celebration Company, gives much more promise of the lode improving in value once it gets out of the zone of impoverishment due to porphyritic influence. This is exemplified by the improvement at the 300 ft. level over that at the 200 ft. level.

At several points, notably on the Celebration Junction Lease, on Lease 81, and on the Jubilee Leases on the continuation of the Celebration line of lode, shoots of payable ore are being developed in the oxidized zone.

The Hampton Properties, Ltd., are developing a very promising lode on Location 45, which is situated about six miles east of the Celebration. The lode has already been proved payable for over 250 ft. in length and down to water-level, 150 ft. Gold has been found on the surface on this line of lode for a considerable distance, both north and south of the present workings, and it is being actively developed.

OTHER DISTRICTS.—At Kalgoorlie the mines are still labouring under the last wages award, while waiting for the Arbitration Court to hear the plaint for a reduction in wages and alteration of unfair conditions, which are more than the low-grade mines can stand.

A new find has been made near Bullfinch, which is attracting the attention of syndicates, but there has not been sufficient work done yet to show whether there is any continuity in values either in length or depth on the lodes. The lodes are covered by several feet of laterite, and do not outcrop.

TORONTO

April 11.

CHANGES IN THE MINING LAW.—A Government Bill now before the Ontario Legislature makes some changes in the mining law, the most important being the abolition of the provision that in order to secure rights to a mining claim the prospector must make oath that he has discovered valuable mineral in place. In practice this is regarded as a mere matter of form, actual discovery before the staking of claims being the exception rather than the rule. Provision is also made for the operation by the Department of Mines of the Timiskaming testing laboratories at Cobalt, at which operators and prospectors can have ore tested in quantity, and for the purchase of small shipments of ore from prospectors.

PORCUPINE.—Towards the end of March operations were somewhat curtailed by power shortage, the power company being able to supply only about 70% of the requirements of the mines. Recent heavy rains have now given an abundant supply of water, and no further recurrence of the trouble is anticipated. There is a very active market for the gold stocks, nearly all the issues having greatly advanced in price. In some cases this has been justified by development and improved conditions, but the general bull movement has also affected many enterprises which are never likely to figure in the dividend-paying class.

A statement of the Dome Mines for the eleven months ended February 28 shows net profits of $524,263, after deducting charges, taxes, and depreciation. The total operating earnings were $1,016,104. The Hollinger Consolidated is applying to the Ontario Government for the right to develop hydro-electric power on the Abitibi River. Adolph Lewisohn & Sons, of New York, have entered the Porcupine field, having contracted to purchase a large block of stock in the Goldale property, which includes fifty claims in fifteen groups. A considerable part of the property lies at the north-east end of Pearl Lake, in line with the strike of the gold deposits of the Hollinger and McIntyre mines. There is also a large acreage adjacent to the Dome Mines. A plan for the exploration and development of the area adjacent to the McIntyre is being prepared. The long-delayed merger of the Dome Lake and West Dome companies is likely to be speedily consummated, as all arrangements have been made subject to ratification by the shareholders. Diamond-drilling has been started on the sand plains lying west of the Hollinger-McIntyre section of the camp, where it is believed that the gold-bearing rock formation continues under a heavy overburden of sand. The Davidson Consolidated has been financed in the British market, where £200,000 of preferred treasury stock of the subsidiary operating company, the Davidson Porcupine, has been underwritten. The plans of the company include the sinking of a shaft to the 1,000 ft. level and the erection of a 500 ton mill. At the Porcupine Peninsula a shaft is down 200 ft. and a drift is being run along a quartz vein 18 ft. wide, stated to carry high gold content.

Kirkland Lake.—The construction programme of the Kirkland Lake Proprietary (1919) is nearing completion. The new central shaft on the Burnside property has been connected with the main zone of mineralization at the 400 ft. level, and has been continued below that point to a depth of 550 ft., where a new level will be opened up. The ore will be crushed at the crusher station at the head of the shaft, and then conveyed by aerial tramway to the mill. The overhauling of the mill has been almost completed, and it will very shortly be in operation. The Lake Shore during February produced $44,082 from the treatment of 1,961 tons of ore, being an average recovery of $22·48 per ton. The Wright-Hargreaves established a new high tonnage record in February, the mill handling an average of over 200 tons daily. Production has recently averaged between $60,000 and $70,000 per month. A dividend of 2½% was declared payable April 1. The merger of the Ontario-Kirkland and the Montreal-Kirkland has been ratified, and a new company organized, capitalized at $5,000,000, which assumes the liabilities of the Ontario-Kirkland. The Ontario-Kirkland shareholders will receive 1,500,000 shares and the Montreal-Kirkland shareholders 1,725,000 shares of the new company. The Teck Hughes has lately been handling an average of 145 tons of ore per day, with mill heads running from $10 to $12 per ton. The grade of ore is expected to be higher when the levels below 600 ft. are opened up. Good progress is being made at the Queen Lebel where the shaft is down 40 ft. and the gold content is stated to increase with depth.

Cobalt.—The annual report of the Nipissing for 1921 shows that the profits have been greatly curtailed by the drop in the price of silver. The production of silver was 3,156,775 oz., and the net profits $969,199, as compared with $1,279,091 in 1920. The cost of production was 28·53 cents per oz., as compared with 37·40 cents in 1920. The ore reserves were reduced by about 500,000 oz., and now stand at 3,004,939 oz. The surplus at the end of the year was $3,851,242. The annual meeting of the La Rose resulted in the re-election of the old directorate, with D. Lorne McGibbon as president, after a protracted struggle, the attempt on the part of Toronto interests to secure the control being defeated by a large majority. The O'Brien mine is now the second largest producer of Cobalt, its output for 1921 being 1,408,890 oz. of silver.

VANCOUVER, B.C.

April 10.

Premier Gold.—The most important feature of the month is the declaration by the Premier Gold Mining Company of a dividend of $500,000 for the three months ended March 31, on its capital of $5,000,000, or at the rate of 40% per annum. It only recently has become known that on December 31 of last year the company distributed a dividend of $400,000, the matter having been kept quiet, it is understood, because the company wanted to add to its holdings. It since either has acquired or has obtained options on a good many claims in the vicinity of its main holding. The achievement is the more remarkable when it is remembered that the tramway was put into operation only at the very close of last year, and that previous to then the shipping of ore from the mine to tide-water was possible only under considerable difficulties and only when there was sufficient snow on the ground to make the sledding good. As a matter of fact much still remains to be done before the mine and plant can be said to be in thorough working order. During the coming summer the hydro-electric plant will be completed, a plant will be built for treating the precipitate from the cyanide plant, which at present is being sent to the Selby smelter, additions will be made to the air-compressing plant, and it is possible that another unit may be added to the concentrating-cyanide plant. Besides this the company will build a number of houses for the accommodation of married men in its employ. It is said that sufficient ore has been proved in the mine to maintain the present rate of production for the next 10 to 15 years, while the limits of the ore-body have not been reached in any direction. During the first three months of this year more than 16,000 tons of ore has been shipped from the mine, the high-grade and concentrate going to Tacoma and the medium grade to Anyox. Recently a scow containing about 500 tons was lost in a storm between Stewart and Anyox, and the company is claiming $20,000 insurance. This places the tenor of the second-grade ore at about $40 per ton. Without doubt the Premier is the most important lode mine that has been discovered in the Province.

CARIBOO.—The rush to the old Cariboo district, predicted in my last letter, is well under way, and the Department of Mines engineers expect that there will be anywhere from five to ten thousand men in the field during the coming summer. Cedar Creek, a tributary to Quesnel Lake, is the centre of the attraction, and the whole country east of Quesnel Lake is being blanketed by leases quite irrespective of what direction the channel takes. These leases are changing hands at anything from $500 up; the discovery lease, owned by Lyne and Platt, is bonded for $200,000. The discoverers have been working their lease steadily through the winter, and are said to have cleaned up $250 daily on an average. The discovery was made on ground 500 ft. above the level of the creek; the gold is coarse and flaky, and, unlike most of the other discoveries that have been made in the Cariboo, carries no "wash." The discovery was made too late last year to enable prospectors to obtain any idea of the direction or extent of the channel of pay ore, and the great majority of the leases that have been staked have been staked on the snow, which is likely to cause no little confusion when they are surveyed. Notwithstanding this, Cedar Creek is on everyone's lips, and, though money is tighter in British Columbia than at any time since the early days of the war, nearly everyone seems to own at least a share in either a gold lease or in an oil lease in Alberta.

Other parts of the Cariboo district, besides Cedar Creek, are receiving their share of attention, and three or four syndicates have expressed their intention of operating dredges during the coming season. Up to now dredging has never been attempted in any part of the district, but during the last few years a good deal of ground has been tested by Keystone drills, and, while no very large area of drillable ground has been discovered so far, sufficient ground has been proved that will run between 50 and 75 cents per cubic yard to guarantee profitable dredging on a small scale.

WHITEWATER.—What seems likely to be an important discovery has been made in the Whitewater district, which lies in a difficult country between the Cariboo district and the coast. This really is a lode-gold discovery, though up to now only the wash from the lode has been worked. The property has been bonded by Joseph Trethewey, who made a fortune at Cobalt and now owns a stock-ranch at Hanceville, which is not very far from the discovery. Mr. Trethewey is taking a diamond-drill to the property and will make a thorough exploration. On the surface the lode is well mineralized and shows gold freely, and a good deal of gold has been cleaned up from the wash that had collected near the outcrop.

REVELSTOKE.—The Waverley Mines Company, which is composed of Spokane and Cheney capitalists, are reopening the Waverley-Tangier groups, in the Revelstoke division. The property is situated 26 miles north of Albert Canyon, on the C.P.R. main line, in a mountainous district, and a good deal of road-work will have to be done before shipping will be possible. The property was operated for a while by the Waverley-Tangier Mining Company, one of the Horne-Payne companies, at the time of the Rossland and Slocan booms, and 15 tons that was shipped to Swansea from the Tangier vein gave a return of 1·5 oz. gold and 130 oz. silver per ton, and 25% of lead; while 40 tons from the Waverley vein gave 0·12 oz. in gold and 160 oz. in silver per ton and 38% in lead. During the past winter the workings have been cleaned out, and it was found that a good deal of driving has been done on both veins, while on the surface the veins have been traced for more than 2,000 ft. Both veins vary considerably in size. In the 100 ft. level the Tangier vein averages about 4 ft. and assays $44·20 per ton in gold, silver, and lead, while in the No. 2 level the

Waverley has a maximum width of 60 ft. with a 14 ft. horse, and assays $36 per ton. As soon as weather conditions allow a good trail will be built to the mine and shipping will be done by Hold caterpillar tractors and trailers.

COAL TROUBLES.—The coal miners' strike, universal throughout the United States, is not greatly affecting this part of Canada, only the miners at the Crow's Nest and southern Alberta fields being out.

OIL.—Two recent oil strikes, one at Kevin, Montana, 15 miles south of the international boundary, and the other in the Medicine Hat Development Company's well, 25 miles north-east of Medicine Hat, have caused a great deal of excitement locally, and a large number of leases have been filed in the Sweetgrass district of Southern Alberta and around the Medicine Hat Company's well. S. E. Slipper, one of the oil experts on the Canadian Geological Survey, after visiting the discovery at Kevin, expressed the opinion that a profitable field had been tapped and that he believed it would extend well into southern Alberta.

SOUTH AFRICA

April 12.

ALL-SLIMING PROCESS IN FAR EAST RAND.—The treatment plant projected for the New State Areas, of 50,000 tons monthly capacity, has been outlined in the *South African Mining Journal.* It would be unreasonable to discuss or criticize in detail the innovations proposed until the designers of the plant have published fully the experimental data and practical results upon which decisions have been based. That a paper before a technical society will be delivered in due course and an opportunity given for opposing schools to analyse and question, will be the wish of all Rand metallurgists, and in accordance with precedent.

The flow-sheet, as published, involves the following noteworthy features: (1) Crushing to 1 in. by horizontal disc crushers, in place of stamps. Without sizing analyses, duties, and cost data, the advantages of this lay-out are not expressible. Although the complete elimination of gravity or power stamps is a radical change, likely to create warm discussion, it is not the most remarkable innovation, in view of the rapid increase in the tube-mill ratio in recent years. (2) Tube-mill plant is noteworthy for the number and magnitude of tubes for the daily capacity, namely, 13 of 20 ft. long by 6½ ft. diameter, for 1,600 to 1,700 tons per day. Dorr classifiers will be installed below the tube-mills and the slime pumped to concrete collectors, for service of agitation tanks 22 ft. in diameter and 49 ft. high. This increase of agitator diameter for reduced capital expenditure, will be productive of valuable data. No amalgamation below the tube-mills will be introduced, a feature directly opposed to the tenets of the old school. (3) Gold extraction will be effected through Butters filter-presses and Merrill zinc-dust presses, in accordance with modern Rand practice for the classified slime product.

Changes in Rand practice, particularly from 1904 to 1914, have been radical enough for so simple an ore, and the possibility of all-sliming was well in view, soon after the introduction of tube-mills from Australia. But the retarding influence has been, in every scheme previously, the economy of recovering the amalgamable gold early and of treating, simply, the sand as sand, in a low-grade ore that yields so readily two-thirds of its gold. With recent practice, a total extraction of 96% has been obtained on an average grade of 7 dwt. The cost of labour stores, and machinery is declining. Treatment expenses should again be brought under 3s. 6d. per ton. Whatever the theoretical gains of the all-cyanidation process, the favourable margins must be very small. But the daring innovations to be made at the New State Areas will be watched with no less interest by the many who have followed the tendencies of Rand metallurgy and have wondered what group would have the audacity to abolish stamps, amalgamation, and sand treatment.

INDUSTRIAL RECOVERY.—The Rand gold-mining companies are recovering rapidly from the effects of the strike. So, indeed, they should. The week of revolution, with which the strike concluded, acted as a strong and salutary purgative, cleansing the body industrial of the deadly poisons injected into every limb during years of communistic doping. The mines are now employing over 13,000 whites, indicating that 8,000 strikers have been re-employed. The native labour shortage is 50,000, as the result of repatriation and normal wastage. At the present juncture, this deficiency is most advantageous. Mine managers (after years of trammelling restrictions) are now enjoying a happy freedom in their selection of men. In the early stages of selection their task is easy, but when the known good workers are re-engaged there is a surplus of men with doubtful records, farm-hands with blasting certificates, and chastened agitators, who demand the most searching inquiry. At the cost of reduced yield and profits, at the cost of retarded development, let the second stage of the recovery be slow and shareholders be patient.

CHAMBER OF MINES POLICY.—There is every indication that the Chamber of Mines intends to change its policy in relation to mine managers as well as to the Trade Unions, regarding the Chamber as the embodiment of Head Office policy. The swing of the pendulum promises to give back to the mine manager the power and authority he enjoyed ten years ago, unless, through the long period of disuse, these functions fail him. A mining engineer has been elected vice-president of the Chamber of Mines. Technical life may be revived in the new earnestness for reduction of costs. Engineering improvements and economies are once again factors of importance. A little scheme of the shift-boss or a reorganization by the mine captain is no longer to be frustrated by a shaft-steward's veto.

The Chamber of Mines has agreed to recognize those Trade Unions which (1) truly represent their trade, (2) provide for a secret ballot before a strike can be called, (3) allow their members to work with non-unionists, and (4) are not represented by any persons hitherto associated with the "Augmented Executive," the S.A. Industrial Federation, or the "Council of Action," which converted the strike into a revolution. This last clause is the most bitter pill for the men to swallow. The demand for a secret ballot is welcomed by the great majority of Trade Unionists, after the travesty of voting by which they were plunged into unemployment and disorder at the new year.

STRIKE CASUALTIES AND BOOTY.—Although it may be the privilege of Parliament to waste time and obstruct progressive legislation by an interminable debate, I hope that the subject of the strike may now be closed in these columns, except for occasional references to its technical issues, to the eventual findings of the Industrial Commission, and to the punishment awarded to the leaders.

In concluding the final chapter, I will quote the official figures giving the measure of the affair from the military standpoint. The casualties numbered :—

	Killed.	Wounded.
Government Forces .	50	237
Civilians (strikers and peaceful citizens .	138	287
Coloured persons .	31	67
	219	591

Captures included : Rifles, 1,150 ; shot-guns, 231 ; revolvers, 745 ; rifle ammunition, 43,519 rounds ; shot-gun ammunition, 3,699 rounds ; revolver ammunition, 13,298 rounds. Also a few machine-guns.

Damage to mine property was comparatively small, owing to the good defence established by mine officials and volunteers and the measure of common-sense retained by the majority of strikers, even in their wilder moments.

It is earnestly hoped by the public, without political passion or thoughts of personal revenge, that the Government will complete the duty so well begun and inflict the death penalty upon the rebel leaders and upon the savage murderers of the Brakpan mine officials, against whom convictions can be obtained.

PERSONAL

P. M. ANDERSON, manager in Johannesburg for the Union Corporation, has been elected a vice-president of the Transvaal Chamber of Mines.

C. A. BANKS is on his way back to northern British Columbia.

G. H. BEATTY has received the Gold Medal of the South African Institution of Engineers for his paper entitled "The New Shaft Development Lay-out at Randfontein Central." This paper was quoted in the MAGAZINE for January, 1921.

EDWIN BERRY is here from New York, and is going to Portugal.

ALEXANDER COLLEDGE has returned from India.

J. V. N. DORR is here from New York.

PRESTON K. HORNER has gone to Bwana M'Kubwa, Rhodesia.

T. J. IVE, chairman of the British Platinum and Gold Corporation, is visiting the company's properties in Colombia.

E. J. C. MEYER, manager of the East Rand Proprietary Mines, has been elected president of the Transvaal Mine Managers' Association.

C. ALGERNON MOREING has been awarded the Grand Cross of the Order of the Nichan Iftikar by the Bey of Tunis.

WALTER J. MORLEY has retired, under the age limit, from the editorship of the *Queensland Goverment Mining Journal.* He had held this position for twenty-two years.

HERBERT L. MORTON has returned from India to England on sick leave.

H. G. PAYNE is returning from South Africa.

Dr. E. S SIMPSON, Government Mineralogist for West Australia, has been appointed to the additional office of Government Chemist and Analyst.

C. E. SKINNER, at present manager of the research department of the Westinghouse Electric Manufacturing Co., of East Pittsburgh, Pennsylvania, has been appointed assistant director of engineering for that company.

C. H. STEWART is back from Venezuela.

S. G. TURRELL has been appointed secretary to the Kalgoorlie branch of the Australasian Institute of Mining and Metallurgy.

LESLIE URQUHART has been in attendance at the Genoa Conference.

R. C. WILSON is acting as State Mining Engineer for West Australia during A. MONTGOMERY's absence in the Eastern States.

W. R. WILSON, manager of the Crow's Nest Pass Coal Company, has been elected president of the Canadian Institute of Mining and Metallurgy.

ROBERT C. STICHT, the general manager of the Mount Lyell mines, Tasmania, died on April 30.

ANDREW MCWILLIAM, a leading steel metallurgist in this country, died on April 5, in his 55th year. He was a brilliant student at the Royal School of Mines, taking the associateship in 1887. Some of his best work was done as assistant professor of metallurgy in Sheffield University, and he was a well-known contributor to the Transactions of the Iron and Steel Institute. He spent seven years in India, first in the service of the Government, and then for a short time with the Tata Iron and Steel Company. Of recent years he was established in Sheffield as a consulting metallurgist.

TRADE PARAGRAPHS

The *Iron and Steel Trades Review* for April 14 publishes an illustrated account of EDGAR ALLEN & Co.'s steel works at Sheffield.

RUSTON & HORNSBY, LTD., of Lincoln, have issued a pamphlet entitled "The Triumph of Oil Fuel," which gives information of use to those who have reasons to wish for a substitute for coal.

THE CONSOLIDATED PNEUMATIC TOOL CO., LTD., of 170, Piccadilly, London, W. 1, announce the new address of their Bombay office, Amarchand Building (Block No. 1, First Floor), Ballard Road, Fort.

NEGRETTI & ZAMBRA, of 38, Holborn Viaduct, London, E.C. 1, are putting on the market a new type of thermometer intended for measuring the surface temperature of rocks, sand, and other materials.

Engineering for April 14 gives an illustrated description of the petrol-electric shovel made by the MARION STEAM SHOVEL COMPANY, of Marion, Ohio; S. Thornley, Mott, & Vines, Ltd., are agents for the Marion shovels in this country.

BROOM & WADE, LTD., of High Wycombe, are putting on the market a portable air-compressor known as the "Typhoon", operated by a petrol or paraffin motor for use in connexion with drilling shot holes in quarries, ironstone mines, or other open workings.

THE BUCYRUS COMPANY, of South Milwaukee, Wisconsin (London office: Iddesleigh House, Caxton Street, S.W. 1), send us a pamphlet relating to their new 30-B Gasoline Shovel. We hope to give a detailed description of this mechanical digger in an early issue.

THE PULSOMETER ENGINEERING CO., LTD., of Reading, have issued a small pamphlet called "Data for Pump Users," which contains formulas, tables, and general data relating to pumping problems. This firm specialize on electrically driven centrifugal and turbine pumps.

THE METROPOLITAN-VICKERS ELECTRICAL CO., LTD., of Trafford Park, Manchester, have received the contract for the supply of switch-gear for the Mangahao hydro-electric installation, New Zealand, which is being erected for the purpose of supplying power to the city of Wellington and its district.

THE ALDEN ENGINE CO., LTD., of Crown Works, Oxford, send us particulars of their electric lighting sets for country houses. The engines employed are of the slow speed vertical paraffin type either belt-driven or direct coupled. The firm make a special feature of the switch-board, and their semi-automatic board has as full an equipment as the ordinary hand-operated board.

THE ATLAS DIESEL CO., LTD., of 35, Surrey Street, London, W.C. 2, send us their pamphlets Le 29, Le 34, and Ke 91. The first-named describes their hammer drills of three types, air-feed with hand-rotated drill steel, hand hammers with hand-rotated drill steel, and hand hammers with automatically rotated drill steel. Le 32 deals with pneumatic tools such as riveters, and Ke 91 with the Atlas air-compressors.

THE HARDINGE COMPANY, of New York, (London office: 11, Southampton Row, W.C. 1), have issued a new condensed bulletin relating to the Hardinge conical mill. This bulletin deals in a concise manner with the principle of operation of the mill, and with its adaptability to industrial and metallurgical grinding problems, and it gives general dimensions of the different types of mills, and tables showing sizes, powers, and capacities for different conditions of grinding.

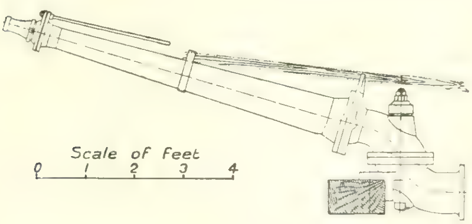
JOHN & EDWIN WRIGHT, LTD., of the Universe Rope Works, Birmingham, recently dispatched what is believed to be the largest flattened strand wire rope that has ever been produced. This is intended for an important haulage work, and it is constructed in one length of seven miles. It is 4⅞ in. in circumference, and weighs 65 tons. As it was too large to be wound on reels in the usual way, it had to be coiled in specially designed railway trucks. It is constructed without splice in either strand or rope, so that it shall be of maximum strength and uniform size throughout its entire length.

NOBEL INDUSTRIES, LTD., of Nobel House, London, S.W. 1, will be represented at the Exhibition at Rio de Janeiro, which is to open on September 7. The company will show commercial explosives and accessories, industrial collodions, shot-gun, rifle, and revolver ammunition, smokeless powders and gunpowder, metals and hardware, motor and cycle accessories, incandescent mantles, petrol lamps and lanterns, art leather cloth, gold and aluminium bronze powders, pure metal alloys, and welding compounds. A similar exhibit is now on show at the British and Latin American Chamber of Commerce, 39, Bedford Square, London, W. 1.

SIR W. G. ARMSTRONG, WHITWORTH & CO., LTD., initiated in May, 1920, a hydro-electric section as a part of their civil engineering department, in order to secure orders for water turbines to be manufactured at their Elswick works to the designs of a well-known Norwegian firm. The volume of business laid before the hydro-electric section since it was first established was so great as to cause the board to decide to form a separate hydro-electric department, as a unit apart from the civil engineering department, as from January 1, 1922. The new department, like the old hydro-electric section, is dealing with complete water-power development schemes throughout all the various stages, and with the various component parts of such schemes. Armstrongs now have survey parties out in many parts of the world looking into projects which have been brought before them for submission to the financial group with whom they are working in the City of London. The offices of the hydro-electric department are at 8, Great George Street, Westminster, S.W. 1, and the department is under the management of Douglas Spencer, who is assisted by such well-known hydro-electric engineers as Robert P. Tod and V. Bataillard, and a large staff of British engineers.

The Gandy Belt Manufacturing Co., Ltd., of Seacombe, near Liverpool, report that they have an order in hand for Gandy patent cotton conveyor-belts, consisting of four belts each 42 in. wide by 10 ply, which are to be shipped to mines in Huelva Province, Spain. Another large installation just completed comprises a number of belts for mines in Carnarvon, one of which is 850 ft. long by 30 in. wide by 8 ply in one continuous length, and weighing nearly 3 tons. Gandy belts have also been supplied to Guernsey granite quarries, where they satisfactorily resist the rough weather and sea spray.

Salterns, Ltd., of Parkstone, Dorset, are putting on the market monitors for hydraulic mining. The monitor shown herewith has an 8 in. diameter flanged inlet pipe of cast steel, and a cast steel connecting pipe to the gun-tube; these are accurately machined and operate on a double



Salterns' Monitor.

ball-bearing fitted with a king bolt, which is of 50-ton tensile steel. The gun-tube is made from an electric welded steel tube, and the nozzle-end is furnished with a water-tight ball-joint, enabling the monitor to be easily swivelled about in any direction. The nozzles supplied are of 2½ in. to 3½ in. for this particular size.

Hyatt, Ltd., of 56, Victoria Street, London, S.W. 1, announce that they have patented a mine tub wheel in which is incorporated their well-known flexible roller bearing. Apart from a saving in lubricating costs of 91% and a saving of nearly 50% in the effort required to haul plain bearing tubs, the design embodies many unique features, those of particular interest being: No inner races, the rollers operating direct on the axle journal. Domed hub end solid with hub wheel with entire absence of any projections or moveable parts. Long hollow flexible rollers which absorb shock loads and distribute the load equally over the entire bearing surface. These hollow flexible rollers also act as lubricant carriers and distributors, each roller having alternate right and left hand spirals, which ensures a constant circulation of lubricant both radially and laterally throughout the bearing. Those interested in the transport on wheels of any material are invited to apply for the comprehensive pamphlet just published by this company on the subject of mine tub practice.

METAL MARKETS

Copper.—The tendency on the standard copper market in London during April was firm, and although quotations fluctuated, a moderate advance was registered on balance. Sentiment was good, it being realized that copper was fairly cheap at the prices ruling, and accordingly values received an appreciable amount of support, with the result that even when large lines of metal were liquidated by tired holders or speculators, the copper was absorbed without much difficulty or damage to prices. It was noticeable that interest did not slacken very appreciably during the Easter holiday period, although, of course, many works closed down for several days. Demand from consumers was better during the month, but, nevertheless, neither English nor Continental consumption is yet satisfactory. It had been hoped that the Genoa Conference would produce tangible results favourable to European trade, but such an anticipation seems likely to prove mistaken, at least as far as the immediate future is concerned. The reduction in the bank rate gave sentiment a fillip, and the impression is gaining ground that the commercial situation in this country is improving. Meanwhile, various Continental countries are putting electrification schemes into operation, and this should result in increased demand from there. In America the market was fairly firm, chiefly on the good sales made by producers during March, but as the price advanced demand fell off, and it does not seem likely that electrolytic there can be held for long for more than 13 cents in the present temper of the New York market. The American position continues obscure owing to the uncertainty of the effect of the fresh production of the recently reopened mines.

Average price of cash standard copper: April, 1922, £58 17s. 2d.; March, 1922, £59 6s. 2d.; April, 1921, £69 8s. 11d.; March, 1921, £67 13s. 3d.

Tin.—At the beginning of the month just elapsed standard tin was in the doldrums, but within the first few days the announcement of a decrease in the visible supplies gave sentiment a much-needed fillip, and a rapid rise occurred. The improvement had the appearance of being genuine, but its rapidity inevitably caused a certain amount of distrust, and a reaction seemed likely. This, however, was largely prevented by the action of professional interests, who came in while the market was wavering, and not only supported values at the new level, but at times pushed them up further. Considerable fluctuations took place, but at the end of the month it seemed doubtful whether values could be maintained at the higher level. On the whole, consuming demand was good. America took some interest in the market, while works in South Wales bought steadily. Continental demand was not very lively, but this was only to be expected. The East sold steadily at reasonable prices, and there did not appear to be much restriction of output going on there. Both Batavia and China, however, were somewhat reserved, the latter being influenced by the movements in the price of silver. It was interesting to note that during the month the Billiton Co. was authorized to dispose of some 2,000 tons of its holding. It would not be surprising if this foreshadows further liquidation of some of the big blocks of metal held in the East and Dutch colonies since the commencement of 1921. English

Daily London Metal Prices: Official Closing
Copper, Lead, Zinc, and Tin per Long Ton

	Copper				
	Standard Cash	Standard (3 mos.)	Electrolytic	Wire Bars	Best Selected
Apr.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.
10	59 15 0 to 59 17 6	60 10 0 to 60 12 6	64 10 0 to 66 10 0	66 5 0 to 66 10 0	— —
11	59 0 0 to 59 2 6	59 12 6 to 60 15 0	64 10 0 to 66 10 0	66 5 0 to 66 10 0	63 0 0 to 65 0 0
12	58 15 0 to 58 17 6	59 10 0 to 59 12 6	64 10 0 to 66 10 0	66 5 0 to 66 10 0	— —
13	59 5 0 to 59 7 6	59 17 6 to 60 0 0	64 10 6 to 66 10 0	63 5 0 to 66 10 0	63 0 0 to 65 0 0
18	59 0 0 to 59 2 6	59 12 6 to 59 15 0	64 10 0 to 66 10 0	66 5 0 to 66 10 0	63 0 0 to 65 0 0
19	58 15 0 to 58 17 6	59 7 6 to 59 10 0	64 0 0 to 66 0 0	65 15 0 to 66 0 0	— —
20	59 2 6 to 59 5 6	59 15 0 to 59 17 6	64 0 0 to 66 0 0	65 15 0 to 66 0 0	— —
21	59 12 6 to 59 15 0	60 5 0 to 60 7 6	64 0 0 to 66 0 0	65 15 0 to 66 0 0	63 0 0 to 65 0 0
24	59 7 6 to 59 10 0	60 2 6 to 60 5 0	64 10 0 to 66 10 0	66 5 0 to 66 10 0	— —
25	59 0 0 to 59 2 6	59 12 6 to 59 15 0	64 10 0 to 66 10 0	66 5 0 to 66 10 0	63 0 0 to 65 0 0
26	59 5 0 to 59 7 6	59 17 6 to 60 0 6	64 10 0 to 66 10 0	66 5 0 to 66 10 0	— —
27	59 0 0 to 59 2 6	59 12 6 to 59 15 0	64 10 0 to 66 10 0	66 5 0 to 66 10 0	— —
28	58 17 6 to 59 0 0	59 10 0 to 59 12 6	64 10 0 to 66 10 0	66 5 0 to 66 10 0	62 10 0 to 64 10 0
May					
1	59 12 6 to 59 15 0	60 5 0 to 60 7 6	64 10 0 to 66 10 0	66 10 0 to 66 10 0	— —
2	60 2 6 to 60 5 0	60 15 0 to 60 17 6	65 0 0 to 67 0 0	67 0 0 to 67 0 0	63 10 0 to 65 10 0
3	60 2 6 to 60 5 0	60 15 0 to 60 17 6	65 0 0 to 67 0 0	67 0 0 to 67 0 0	— —
4	60 0 0 to 60 2 6	60 10 0 to 60 12 6	65 0 0 to 67 0 0	67 0 0 to 67 0 0	— —
5	59 17 6 to 60 0 0	60 7 6 to 60 10 0	65 0 0 to 67 0 0	67 0 0 to 67 0 0	63 10 0 to 65 10 0
8	60 5 0 to 60 7 6	60 12 6 to 60 15 0	65 0 0 to 67 0 0	67 0 0 to 67 0 0	— —
9	60 5 0 to 60 7 6	60 12 6 to 60 15 0	65 0 0 to 67 0 0	67 0 0 to 67 0 0	63 10 0 to 65 10 0

tin was well held during the month, and inquiry for this description was sufficient to absorb the limited output.

Average price of cash standard tin: April, 1922, £149 18s. 11d.; March, 1922, £143 5s.; April, 1921, £164 0s. 11d.; March, 1921, £156 4s. 7d.

LEAD.—The London lead market exhibited considerable firmness during April. Holders had the position well under control, and held available supplies firmly, with the result that consumers found themselves forced to buy on a steadily rising market. Arrivals of fresh metal tended to decrease, while the market was supported by the apprehension that supplies would fall away further. With the mining strike in Spain progressing, and with advices of restricted shipments from Australia, there was certainly good reason to fear that the position would become still tighter in the near future. The advance in prices rather discouraged consumers in the United Kingdom, but a fair amount of Continental inquiry was manifest, possibly owing to consumers there finding themselves cut off from their Spanish supplies. Towards the end of the month rumours of the termination of the Penarroya strike and the fear of larger shipments from Spain in consequence eased prices temporarily, particularly for forward. As a result, the backwardation widened to about 20s. America did not feature as a large seller to this country during the month. The market closed with a firm tone.

Average price of soft foreign lead: April, 1922, £22 14s. 1d.; March, 1922, £21 3s.; April, 1921, £20 16s. 10d.; March, 1921, £19 2s. 9d.

SPELTER.—During the month the spelter market displayed a firm, though on the whole quiet, aspect. No improvement took place in the volume of fresh supplies, and any anticipations which had been held of a modification in the attitude of foreign producers proved unfounded. Despite the fact that world production is gradually expanding, this has so far had no tangible effect on the London market. The Belgian smelters have been remarkably active during the past few months, but nevertheless no increased selling pressure on their part is evident, while the German-Polish producers have held entirely aloof. Some of the English works were offering fairly keenly, having got back to a producing basis again, but the quantities available from this source are not large yet. Meanwhile, the expected shipments from America failed to materialize, owing to the firmness of the market there, which lessened the attractiveness of sales to Europe. Nor has the big Tasmanian output so far made its presence felt. English consuming demand during April was pretty good, thanks to a revival in the galvanizing industry, which, latterly, has been quieter; but when the brass trade begins to awaken a further broadening in demand should occur. The immediate future seems a little involved, but the time certainly appears to be approaching when supplies should undergo a substantial improvement. A feature of the month was the appearance of a backwardation in the quotation, which is a clear indication of the tightness of prompt supplies.

Average price of spelter: April, 1922, £26 10s. 10d.; March, 1922, £25 10s. 5d.; April, 1921, £26 1s. 5d.; March, 1921, £25 10s. 5d.

ZINC DUST.—Values have remained unchanged as follow: Australian high-grade £50, American 92 to 94% £47 10s., and English 90 to 92% £45 per ton, all rather nominal.

ANTIMONY.—Quotations are steady, English regulus being still priced at £29 5s. to £33 per ton for ordinary brands, and at £32 10s. to £35 for special brands. Foreign regulus on spot is maintained at £24 to £24 10s. ex warehouse, but a lower figure would possibly be accepted for a substantial export order.

ARSENIC.—The market is somewhat firmer, home supplies being short, and but little foreign available. The price is about £39 per ton delivered London, showing an increase of about £2 on the month.

BISMUTH.—The market continues steady at 9s. to 10s. per lb.

CADMIUM.—A firmer tone is evident, with the price slightly higher at 5s. 9d. per lb.

Prices on the London Metal Exchange.

Silver per Standard Ounce; Gold per Fine Ounce.

Lead: Soft Foreign	Lead: English	Zinc (Spelter)	Standard Tin: Cash	Standard Tin: 3 mos.	Silver: Cash	Silver: Forward	Gold	
£ s. d. £ s. d.	£ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	d.	d.	s. d.	Apr.
22 7 6 to 21 17 6	23 10 0	26 7 6 to 26 7 6	152 5 0 to 152 10 0	153 15 0 to 154 0 0	33½	33½	93 9	10
22 15 0 to 22 5 0	24 0 0	26 10 0 to 26 10 0	150 5 0 to 150 10 0	151 15 0 to 152 0 0	33½	33½	93 5	11
22 12 6 to 22 5 0	24 0 0	26 10 0 to 26 10 0	148 5 0 to 148 10 0	149 15 0 to 150 0 0	33¼	33⅜	93 5	12
22 15 0 to 22 5 0	24 0 0	26 12 6 to 26 12 6	151 10 0 to 151 15 0	153 0 0 to 153 5 0	33⅜	33⅜	—	13
22 15 0 to 22 5 0	24 0 0	26 15 0 to 26 15 0	152 15 0 to 153 0 0	154 0 0 to 154 5 0	33⅝	33⅝	93 4	18
22 17 6 to 22 7 6	24 5 0	26 17 6 to 26 15 0	151 15 0 to 152 0 0	153 2 6 to 153 5 0	35⅞	35⅞	93 6	19
23 2 6 to 22 12 6	24 5 0	26 17 0 to 26 15 0	153 2 6 to 153 5 0	154 10 0 to 154 12 6	34¾	34¾	93 6	20
23 15 0 to 23 5 0	25 0 0	27 0 0 to 26 17 6	155 15 0 to 156 0 0	157 5 0 to 157 10 0	34¾	34¾	93 5	21
24 2 6 to 23 12 6	25 5 0	27 5 0 to 27 0 0	153 5 0 to 153 10 0	154 15 0 to 155 0 0	34¾	34¾	93 5	24
24 7 6 to 23 15 0	25 10 0	27 5 0 to 27 2 6	151 10 0 to 151 15 0	153 0 0 to 153 5 0	34½	34½	93 0	25
24 2 6 to 23 5 0	25 5 0	27 5 0 to 27 0 0	152 10 0 to 152 15 0	154 0 0 to 154 5 0	34½	34½	93 3	26
24 7 6 to 23 7 6	25 5 0	26 17 6 to 26 12 6	151 5 0 to 151 10 0	152 12 6 to 153 0 0	34½	34½	93 3	27
24 12 6 to 23 10 0	25 10 0	26 17 6 to 26 15 0	151 0 0 to 151 5 0	152 10 0 to 152 12 6	34¾	34½	93 3	28
								May
24 0 0 to 23 0 0	25 0 0	26 17 6 to 26 15 0	151 10 0 to 151 12 6	152 17 6 to 153 0 0	34⅞	34⅞	93 3	1
24 0 0 to 23 0 0	25 0 0	27 2 6 to 27 0 0	152 5 0 to 152 7 6	153 15 0 to 153 17 6	35	35	93 1	2
23 15 0 to 22 17 6	25 0 0	27 7 6 to 27 5 0	150 0 0 to 150 5 0	151 7 6 to 151 12 6	35	35	93 1	3
24 0 0 to 23 0 0	25 0 0	27 0 0 to 26 17 6	148 10 0 to 148 15 0	150 2 6 to 150 5 0	35¼	35⅜	93 2	4
24 0 0 to 23 2 6	25 0 0	27 0 0 to 26 17 6	149 15 0 to 150 0 0	151 2 6 to 151 5 0	35½	35½	93 3	5
24 7 6 to 23 7 6	25 10 0	27 2 6 to 27 0 0	149 5 0 to 149 10 0	150 15 0 to 151 0 0	35½	35⅛	93 3	8
24 10 0 to 23 2 6	25 10 0	27 5 0 to 27 2 6	148 15 0 to 149 0 0	150 5 0 to 150 10 0	35⅜	35⅜	95 4	9

Aluminium.—Official quotations are maintained at £120 for home and £125 for export, but home business could probably be transacted at about £100. Canadian is offering at about £93 delivered United Kingdom, and foreign at about £87 10s. f.o.b. Continent.

Nickel.—There is very little doing, and although prices are nominally £162 10s. for home and export, business can be done in foreign at about £155 to £160 per ton f.o.b. Continent.

Cobalt Metal.—The market is quiet and unchanged at 12s. per lb.

Cobalt Oxides.—A little more inquiry is about, with prices unchanged at 9s. for black and 10s. per lb. for grey.

Platinum.—Quotations are steady and unchanged at £19 per oz. for manufactured, and £17 per oz. for raw.

Palladium.—There is not a lot doing, and quotations keep steady at £16 per oz. for sheets and wire, and £12 10s. per oz. for raw.

Quicksilver.—The spot market quotation shows no change at £10 15s. per bottle, although more inquiry has been about lately. Italy is firm in her ideas of prices, which are above those ruling here.

Selenium.—The market is easier, with powder quoted at 7s. 9d. per lb.

Tellurium.—This market has also eased off somewhat, and there are now sellers down to 40s. per lb.

Sulphate of Copper.—There has been no change during the month, both home and export business being quoted at £27.

Manganese Ore.—Indian grades are quoted at 1s. 1d. to 1s 1½d. per unit, and Caucasian is quiet at 1s. 2d. per unit c.i.f.

Tungsten Ore.—There is considerably better demand, and the price of 65% WO_3 has firmed up to about 11s. 6d. per unit c.i.f.

Molybdenite.—The market is easier, with quotations about 27s. 6d. to 30s. per unit c.i.f. for 85%.

Chrome Ore.—Export demand is moderately good, but home business is quiet. The price is about £4 to £4 5s. c.i.f.

Silver.—The aspect of the London silver market at the commencement of April was quiet and steady. Spot bars on April 1 were quoted at 33⅝d., and very little change took place during the first two weeks or so, the quotation on the 18th being 33⅝d. On the 19th, however, heavy Chinese buying took place, possibly as a result of the threat of civil war in China, and the price was forced up to 35⅞d. On the 20th a reaction occurred to 34¾d., China making some re-sales. Subsequently the market was fairly steady, and the quotation closed the month at 34⅞d. on April 29.

Graphite.—There is not much doing, and we call Madagascar, 80 to 90%, steady at about £16 per ton c.i.f.

Iron and Steel.—Though the April shipments for both pig iron and steel from this country will show that trade has made good strides this year, conditions in the home trade are in such an appalling state that the present outlook is by no means bright. Throughout last month the two industrial disputes continued unsettled, with the result that the home buying of steel has been practically at a minimum, if any at all. On top of this must be added the period of inactivity during the Easter vacation, with the result that few steel works had got going again by the end of the month, having practically no accumulation of specifications on hand. There seems to be a good demand for export, and some fair business could be done at a price, but producers cannot see their way to going any further below cost, which they would have to do to get business. It is encouraging to note that the Continent has not been taking so much business lately, and this is mainly due to the fact that buyers do not favour the long-delayed deliveries, even though the price is comparatively cheap. Pig iron has been brisker, being cheaper than the Continent, on sustained demand from that side, but prices of foundry pig have been unchanged at 90s. for No. 3 G.M.B. Cleveland. Hematite is weaker at 96s.

STATISTICS

Production of Gold in the Transvaal.

	Rand	Elsewhere	Total	Price of
	Oz.	Oz.	Oz.	Gold per oz.
				s. d.
April, 1921	665,309	16,073	681,382	103 9
May	671,750	16,026	687,776	103 9
June...........	663,383	15,107	678,490	107 6
July	673,475	16,080	689,555	112 6
August..........	695,230	16,296	711,526	111 6
September.......	674,157	16,939	691,096	110 0
October	690,348	17,477	707,825	103 0
November	688,183	16,053	704,236	102 0
December	664,935	16,912	681,847	95 6
Total, 1921......	7,924,534	190,052	8,114,586	—
January, 1922 . February...... March	594,788	44,940	639,728	95 6 92 6 94 0

Natives Employed in the Transvaal Mines.

	Gold mines	Coal mines	Diamond mines	Total
January 31, 1921 ...	165,287	14,541	3,319	183,147
February 28	171,518	14,697	1,612	187,827
March 31	174,364	14,906	1,364	190,634
April 30	172,826	14,908	1,316	189,050
May 31	170,595	14,510	1,302	186,407
June 30	168,152	14,704	1,317	184,173
July 31	166,999	14,688	1,246	182,933
August 31	169,008	14,446	1,207	184,661
September 30	171,912	14,244	1,219	187,375
October 31	175,331	13,936	1,223	190,490
November 30	176,410	13,465	1,217	191,092
December 31........	177,836	13,280	1,224	192,340
March 31, 1922	124,169	11,155	1,204	136,528

Cost and Profit on the Rand.

Compiled from official statistics published by the Transvaal Chamber of Mines. Figures for yield include premium.

	Tons milled	Yield per ton	Work'g cost per ton	Work'g profit per ton	Total working profit
		s. d.	s. d.	s. d.	£
January, 1921	1,895,235	35 0	26 3	8 9	829,436
February	1,575,320	35 6	28 6	7 0	550,974
March	1,958,730	34 5	26 1	8 4	813,636
April	1,991,815	34 5	25 10	8 7	854,533
May	1,955,357	35 3	26 2	9 1	889,520
June	1,966,349	35 10	25 10	10 0	979,769
July.........	2,010,236	37 2	25 7	11 7	1,163,565
August	2,050,722	37 3	25 4	11 11	1,226,282
September ...	1,997,086	36 8	25 2	11 6	1,151,127
October......	2,041,581	34 4	24 9	9 7	981,597
November ..	2,007,617	34 6	24 9	9 9	978,931
December....	1,954,057	31 11	24 11	7 0	683,565

Production of Gold in Rhodesia.

	1920	1921	1922
	oz.	oz.	£
January	43,428	46,956	53,541
February	44,237	40,816	51,422
March	45,779	31,995	54,643
April	47,000	47,858	
May............	46,266	48,744	—
June	45,054	49,466	
July	46,208	51,564	—
August	48,740	53,200	
September	45,471	52,436	—
October	47,343	53,424	—
November	46,782	53,098	—
December	46,190	55,968	—
Total	552,498	591,525	159,606

Transvaal Gold Outputs.

	February		March	
	Treated Tons	Yield Oz.	Treated Tons	Yield Oz.
Aurora West..........	—	—	8,409	£10,668*
Brakpan	—	—	30,548	15,136
City Deep	—	—	55,600	32,162
Cons. Langlaagte	—	—	36,000	£51,710*
Cons. Main Reef	—	—	42,170	18,867
Crown Mines..........	—	—	146,600	53,104
D'rb'nRoodepoortDeep	—	—	27,393	8,091
East Rand P.M.........	—	—	105,200	23,845
Ferreira Deep	—	—	20,960	5,430
Geduld...............	—	—	50,500	19,078
Geldenhuis Deep	—	—	35,936	9,962
Glynn's Lydenburg ...	3,770	£6,635‡	4,370	£8,074§
Goch	—	—	18,700	£19,558*
Government G.M. Areas	—	—	115,500	£263,579*
Kleinfontein	—	—	—	—
Knight Central........	—	—	34,570	8,063
Langlaagte Estate	—	—	36,806	£49,654*
Luipaard's Vlei	—	—	—	—
Meyer & Charlton	—	—	14,522	£41,600*
Modderfontein, New ..	—	—	65,000	40,406
Modderfontein B	—	—	47,000	23,082
Modderfontein Deep ..	—	—	56,600	32,955
Modderfontein East....	—	—	13,750	5,919
New Unified	—	—	12,700	£9,937*
Nourse	—	—	43,550	13,367
Primrose	—	—	16,006	£17,028*
Randfontein Central ..	—	—	76,100	£105,896*
Robinson.............	—	—	20,300	6,715
Robinson Deep	—	—	52,309	£85,370*
Roodepoort United ...	—	—	14,707	£12,538*
Rose Deep	—	—	54,160	14,346
Simmer & Jack	—	—	59,900	£73,778*
Springs	—	—	27,690	10,468
Sub-Nigel	—	—	14,600	£46,347*
Transvaal G.M. Estates.	14,355	£25,334‡	16,290	£26,314§
Van Ryn	—	—	24,058	£35,197*
Van Ryn Deep	—	—	45,210	£101,620*
Village Deep	—	—	43,150	13,596
West Rand Consolidated	—	—	39,440	£47,505*
Witw'tersr'nd (Knights)	—	—	47,420	£52,151*
Witwatersrand Deep ..	—	—	27,016	£41,691*
Wolhuter............	—	—	32,055	7,249

The March figures for mines on the Rand include all crushings since January 1.

* £4 15s. 6d. per oz. for January; £4 12s. 6d. for February; £4 14s. for March. ‡ £4 10s. 6d. per oz. § £4 12s. per oz.

Rhodesian Gold Outputs.

	February.		March.	
	Tons	Oz.	Tons	Oz.
Cam & Motor	14,100	5,036	14,100	6,530
Falcon	15,004	3,044‖	15,534	3,010*
Gaika	3,868	1,386	4,018	£7,303
Globe & Phœnix	5,912	5,188	6,346	5,407
Jumbo	1,350	465	1,320	521
London & Rhodesian ..	3,752	£3,679	4,439	£4,564
Lonely Reef	5,200	4,655	5,570	4,957
Planet-Arcturus	5,730	2,233	6,020	2,305
Rezende	5,500	2,704	—	—
Rhodesia G.M. & I. ..	246	330	229	299
Shamva	48,700	£37,729§	59,000	£37,946‡
Transvaal & Rhodesian	—		1,650	5,160

* Also 277 tons copper. † At par. ‖ Also 283 tons copper. § Gold at £4 15s. per oz. ‡ Gold at £4 12s. 6d. per oz.

West African Gold Outputs.

	February		March	
	Tons	Oz.	Tons	Oz.
Abbontiakoon	7,350	£11,759*	8,400	£14,032*
Abosso	6,600	2,686	7,350	2,954
Ashanti Goldfields	6,161	5,880	7,677	6,575
Obbuassi	511	£2,455†	478	£1,910†
Prestea Block A.......	7,033	£14,346*	8,323	£15,085*
Taquah	2,960	1,911	2,900	1,757

* At par. † Including premium.

West Australian Gold Statistics.—Par Values.

	Reported for Export Oz.	Delivered to Mint Oz.	Total Oz.	Par Value £
July, 1921	1,641	44,917	46,558	197,774
August	110	51,731	51,841	220,205
September	380	50,728	51,108	217,092
October	1,910	51,286	53,196	225,959
November	156	46,429	46,585	197,879
December	451	53,348	53,799	228,522
January, 1922	329	37,851	38,180	162,177
February	926	41,194	42,120	178,913
March	180	42,842	43,022	182,745
April	1,237	45,157	46,394	197,068

Australian Gold Outputs.

	West Australia	Victoria	Queensland	New South Wales
	oz.	oz.	oz.	£
January	38,181	4,411	448	11,855
February	42,121	8,063	1,200	12,325
March	43,022	—	—	12,960
April	46,394	—	—	—
May	—	—	—	—
June	—	—	—	—
July	—	—	—	—
August	—	—	—	—
September	—	—	—	—
October	—	—	—	—
November	—	—	—	—
December	—	—	—	—
Total	169,718	12,474	1,648	37,140

Australasian Gold Outputs.

	February		March	
	Tons	Value £	Tons	Value £
Associated G.M. (W.A.)	5,528	8,129‖	6,370	8,3[illegible]2‖
Blackwater (N.Z.)	2,869	5,733*	3,871	7,911*
Gold'n Horseshoe (W.A)	9,408	5,048‡	10,524	5,472‡
Grt Boulder Pro. (W.A.)	8,274	24,822‖	9,893	29,679‖
Ivanhoe (W.A.)	13,346	5,814‡	15,997	6,788‡
Lake View & Star (W.A.)	5,991	10,728‖	6,471	12,881‖
Oroya Links (W.A.)	1,716	9,927‖†	1,418	6,401‖†
South Kalgurli (W.A.)	6,422	10,586‖	7,256	12,442‖
Waihi (N.Z.)	25,856*e*	7,077‡ 44,079§	12,868	3,699‡ 11,484§
,, Grand Junc'n (N.Z.)	9,280*f*	2,425‡ 8,344§	—	—

* Including premium ; † Including royalties ; ‡ Oz. gold ; § Oz. silver ; ‖ At par ; *e*, 8 weeks to March 18 ; *f*, Jan., Feb., March.

Miscellaneous Gold and Silver Outputs.

	February.		March	
	Tons	Value £	Tons	Value £
Brit. Plat. & Gold (C'lbia)	—	279*p*	—	279*p*
El Oro (Mexico)	30,780	176,481†	35,028	188,326†
Esperanza (Mexico)	—	—	—	1,760*e*
Frontino & Bolivia (C'lbia)	1,800	7,488	1,900	5,777
Keeley Silver (Canada)	—	45,000*s*	—	59,000*s*
Mexico El Oro (Mexico)	12,060	195,060†	13,000	195,900†
Mining Corp. of Canada	—	—	—	—
Oriental Cons. (Korea)	—	73,700†	—	91,000†
Ouro Preto (Brazil)	6,800	2,558‖	7,700	2,598‖
Plym'th Cons. (Calif'rnia	7,000	8,024*	8,000	9,609*
St. John del Rey (Brazil)	—	59,000*	—	44,000*
Santa Gertrudis (Mexico)	32,297	58,478*e*	33,289	58,156*e*
Tomboy (Colorado)	16,000	75,000†	18,000	71,000†

* At par. † U.S. Dollars. ‡ Profit, gold and silver. ‖ Oz. gold. *p* Oz. platinum and gold. *s* Oz. silver. *e* Profit in dollars.

Pato (Colombia) : 19 days to April 1, $16,800 from 103,389 cu. yd. ; 11 days to April 12, $11,220 from 67,019 cu. yd.

Indian Gold Outputs.

	February		March	
	Tons Treated	Fine Ounces	Tons Treated	Fine Ounces
Balaghat	3,000	2,324	3,250	2,482
Champion Reef	10,632	4,905	11,628	4,910
Mysore	17,467	10,519	18,318	10,502
North Anantapur	550	601	550	595
Nundydroog	8,242	4,753	9,636	5,028
Ooregum	15,500	8,168	13,000	8,598

Production of Gold in India.

	Reported by English mining companies.				Total.
	1918	1919	1920	1921	1922
	Oz.	Oz.	Oz.	Oz.	Oz.
January	41,420	38,184	39,073	34,028	35,493
February	40,787	36,384	38,872	32,529	—
March	41,719	38,317	38,760	32,576	—
April	41,504	38,248	37,307	32,363	—
May	40,889	38,608	38,191	32,656	—
June	41,264	38,359	37,864	32,207	—
July	40,229	38,549	37,129	32,278	—
August	40,496	37,850	37,375	32,498	—
September	40,088	36,813	35,497	32,642	—
October	39,472	37,138	35,023	32,186	—
November	36,984	39,628	34,522	32,293	—
December	40,149	42,643	34,919	32,578	—
Total	485,236	461,171	444,532	390,549	35,493

Base Metal Outputs.

		Feb.	Mar.
Broken Hill British	Tons lead carb. ore.	—	385
	Tons lead conc.	2,805	2,750
	Tons zinc conc.	2,010	2,140
Broken Hill Prop.	Tons lead conc.	1,638	1,643
	Tons zinc conc.	6,464	6,105
Broken Hill South	Tons lead conc.	4,447	4,970
Burma Corporation	Tons refined lead	3,016	3,250
	Oz. refined silver	299,223	332,000
Electrolytic Zinc	Tons zinc	1,457	1,581
Mount Lyell	Tons copper	576	217
	Oz. silver	16,533	4,067
	Oz. gold	319	53
Mount Morgan	Tons copper	—	360
	Oz. gold	—	4,500
North Broken Hill	Tons lead conc.	1,750	1,960
	Tons zinc conc.	1,720	1,830
Pilbara	Tons copper ore	-	—
Poderosa	Tons copper ore	560	700
Rhodesia Broken Hill	Tons lead	1,735	1,981
Sulphide Corporation	Tons lead conc.	2,106	2,461
	Tons zinc conc	3,425	4,114
Tanganyika	Tons copper	2,624	3,057
Transvaal Silver	Tons silver-lead bullion	—	365
Zinc Corporation	Tons zinc conc.	8,255	876
	Tons lead conc.	722	9,400

Imports of Ores, Metals, etc., into United Kingdom.

		Feb.	Mar.
Iron Ore	Tons	225,939	221,812
Manganese Ore	Tons	6,884	11,141
Iron and Steel	Tons	64,609	63,842
Copper and Iron Pyrites	Tons	19,435	33,575
Copper Ore, Matte, and Prec.	Tons	471	260
Copper Metal	Tons	3,237	5,619
Tin Concentrate	Tons	3,034	2,271
Tin Metal	Tons	2,745	2,911
Lead, Pig and Sheet	Tons	15,981	13,429
Zinc (Spelter)	Tons	4,049	6,031
Zinc Sheets, etc.	Tons	853	840
Quicksilver	Lb.	105,448	93,530
Zinc Oxide	Tons	465	455
White Lead	Cwt.	7,755	7,756
Barytes, ground	Cwt.	28,987	42,471
Asbestos	Tons	666	1,398
Phosphate of Lime	Tons	8,579	42,134
Mica	Tons	102	99
Sulphur	Tons	7,276	965
Nitrate of Soda	Cwt.	124,756	62,178
Petroleum : Crude	Gallons	11,740,093	18,825,520
Lamp Oil	Gallons	13,928,360	13,219,351
Motor Spirit	Gallons	23,475,208	27,494,464
Lubricating Oil	Gallons	4,323,828	5,537,906
Gas Oil	Gallons	4,327,187	5,372,704
Fuel Oil	Gallons	36,406,977	25,970,170
Asphalt and Bitumen	Tons	2,628	5,536
Paraffin Wax	Cwt.	61,041	65,519
Turpentine	Cwt.	14,635	49,267

Outputs of Tin Mining Companies.

In Tons of Concentrate.

	Jan.	Feb.	Mar.
	Tons	Tons	Tons
Nigeria :			
Bisichi	33	30	33
Ex-Lands	30	30	30
Filani	1¾	2	2½
Gold Coast Consolidated	3	—	—
Gurum River	9	8	9
Jos	9	10¾	11
Kaduna	22	20	22¾
Kaduna Prospectors	15¾	14¼	20⅛
Keffi Consolidated	22	20	20
Lower Bisichi	4½	4	3¼
Mongu	56¼	36¼	37¼
Naraguta	60	55	55
Naraguta Extended	12	6	5
Nigerian Consolidated	10¼	10	11
N.N. Bauchi	50	45	40
Rayfield	37	39	40
Ropp	109	81	126
Rukuba	4	4	4
South Bukeru	12	16	20
Tin Fields	—	—	8
Yarde Kerri	9	11	10
Federated Malay States :			
Chenderiang	—	—	72*
Gopeng	71½	54	65½
Idris Hydraulic	23¾	19½	19½
Ipoh	21	12¼	9½
Kamunting	—	—	82*
Kinta	38¾	41¾	42¼
Lahat	27½	26¾	21½
Malayan Tin	68½	74½	78¾
Pahang	251	230	233
Rambutan	21	18	18
Sungei Besi	36	36	39
Tekka	36	39	42
Tekka-Taiping	21	28	30
Tronoh	17	25	76½
Other Countries :			
Aramayo Mines (Bolivia)	250	234	235
Berenguela (Bolivia)	41	29	32
Briseis (Tasmania)	—	—	—
Deebook Ronpibon (Siam)	—	29	29
Leeuwpoort (Transvaal)	—	—	—
Macreedy (Swaziland)	—	—	—
Renong (Siam)	82	62	77
Rooiberg Minerals (Transvaal)	—	—	—
Siamese Tin (Siam)	103¾	86¼	103¼
Tongkah Harbour (Siam)	95	82	75
Zaaiplaats (Transvaal)	—	—	—

* Three months.

Nigerian Tin Production.

In long tons of concentrate of unspecified content.

Note.—These figures are taken from the monthly returns made by individual companies reporting in London, and probably represent 85% of the actual outputs.

	1917	1918	1919	1920	1921	1922
	Tons	Tons	Tons	Tons	Tons	Tons
January	667	678	613	547	438	473
February	646	668	623	477	370	412
March	655	707	606	505	445	453
April	555	584	546	467	394	—
May	509	525	483	383	337	—
June	473	492	484	435	423	—
July	479	545	481	484	494	—
August	551	571	616	447	477	—
September	538	520	561	528	595	—
October	578	491	625	625	546	—
November	621	472	536	544	564	—
December	655	518	511	577	555	—
Total	6,927	6,771	6,685	6,022	5,618	1,338

Production of Tin in Federated Malay States.

Estimated at 70% of Concentrate shipped to Smelters
Long Tons.

	1918	1919	1920	1921	1922
	Tons	Tons	Tons	Tons	Tons
January	3,030	3,765	4,265	3,298	3,143
February	3,197	2,734	3,014	3,111	2,572
March	2,609	2,819	2,770	2,190	2,839
April	3,308	2,858	2,606	2,692	—
May	3,332	3,407	2,741	2,884	—
June	3,070	2,877	2,940	2,752	—
July	3,373	3,756	2,824	2,734	—
August	3,259	2,956	2,786	3,051	—
September	3,157	3,161	2,734	2,338	—
October	2,870	3,221	2,837	3,161	—
November	3,132	2,972	2,573	2,800	—
December	3,022	2,409	2,838	3,435	—
	37,370	36,935	34,928	34,446	8,544

Stocks of Tin.

Reported by A. Strauss & Co. Long Tons.

	Feb. 28	Mar. 31	Apr. 30
Straits and Australian Spot	1,668	1,439	1,351
Ditto, Landing and in Transit	627	340	175
Other Standard, Spot and Landing	5,175	4,990	5,627
Straits, Afloat	875	1,050	875
Australian, Afloat	190	90	75
Banca, in Holland	4,766	3,756	2,884
Ditto, Afloat	600	230	651
Billiton, Spot	100	95	83
Billiton, Afloat	—	—	—
Straits, Spot in Holland and Hamburg	—	—	—
Ditto, Afloat to Continent	500	525	740
Total Afloat for United States	8,527	5,437	6,052
Stock in America	1,406	3,086	2,721
Total	24,434	21,040	21,244

Shipments, Imports, Supply, and Consumption of Tin.

Reported by A. Strauss & Co. Long tons.

	Feb.	Mar.	Apr.
Shipments from :			
Straits to U.K.	875	1,000	825
Straits to America	2,255	3,455	3,800
Straits to Continent	510	530	725
Straits to other places	305	325	175
Australia to U.K.	200	130	25
U.K. to America	975	745	414
Imports of Bolivian Tin into Europe	770	1,474	411
Supply :			
Straits	3,565	4,985	5,350
Australian	200	130	130
Billiton		10	—
Banca	1,038	265	1,560
Standard	587	706	890
Total	5,390	6,096	7,930
Consumption :			
U.K. Deliveries	2,228	2,659	2,009
Dutch „	426	251	75
American „	3,215	6,030	4,995
Straits, Banca & Billiton, Continental Ports, etc.	433	550	647
Total	6,302	9,490	7,726

Imports and Exports of Gold and Silver

During March, 1922.

		Imports.	Exports.
Gold :	Unrefined Bullion.... £	368,444	—
	Refined Bars........ „	343,251	737,192
	Coin .... „	1,173	446,482
Silver :	Unrefined Bullion ... oz.	115,742	—
	Refined Bars........ „	6,987,736	10,569,084
	Coin .... £	202,286	328,477

Outputs Reported by Oil-producing Companies.

		Jan.	Feb.	Mar.
Anglo-Egyptian	Tons..	10,254	13,579	15,435
Anglo-United	Barrels	6,700	4,260	7,325
Apex Trinidad	Barrels	38,799	23,409	46,124
British Burmah	Barrels	71,735	63,459	75,257
Caltex	Tons..	10,443	10,335	7,492
Dacia Romana	Tons..	304	213	211
Kern River	Barrels	110,627	106,075	115,616
Lobitos	Tons..	9,003	8,181	9,123
Roumanian Consolidated	Tons..	1,600	1,616	1,763
Santa Maria	Barrels	12,500	11,700	12,700
Steaua Romana	Tons .	18,101	15,600	18,300
Trinidad Leaseholds	Tons..	10,800	8,400	9,050
United of Trinidad	Tons..	3,398	3,486	3,469

Quotations of Oil Companies' Shares.

Denomination of Shares £1 unless otherwise noted.

	Apr. 5, 1922			May 5, 1922		
	£	s.	d.	£	s.	d.
Anglo-American	4	0	0	4	16	3
Anglo-Egyptian B	1	11	0	1	16	3
Anglo-Persian 1st Pref.	1	4	0	1	5	0
Apex Trinidad	1	10	0	2	0	0
British Borneo (10s.)		8	9		12	6
British Burmah (8s.)		13	6		15	0
Burmah Oil	5	13	6	5	16	3
Caltex ($1)		2	6		2	6
Dacia Romano		12	6		15	0
Kern River, Cal. (10s.)	1	2	3	1	4	3
Lobitos, Peru	4	16	0	5	0	0
Mexican Eagle, Ord. ($5)	3	12	6	3	8	9
„ „ Pref. ($5)	3	10	0	3	6	3
North Caucasian (10s.)		13	6		13	9
Phœnix, Roumania	1	9	0	1	7	0
Roumanian Consolidated		13	6		14	6
Royal Dutch (100 gulden)	39	1	0	43	0	0
Scottish American		2	6		2	6
Shell Transport, Ord.	4	18	9	5	8	9
„ „ Pref. (£10)	9	5	0	9	15	0
Trinidad Central	3	5	0	2	15	0
Trinidad Leaseholds	1	5	6	1	6	3
United British of Trinidad		11	0		12	6
Ural Caspian		16	0		17	6
Uroz Oilfields (10s.)		7	0		12	6

Petroleum Products Prices. May 9.

Refined Petroleum: Water white, 1s. 2d. per gallon; standard white, 1s. 1d. per gallon; in barrels 3d. per gallon extra.

Motor Spirit: In bulk: Aviation spirit, 2s. 6d. per gallon; No. 1, 2s. 2d. per gallon; No. 2, 2s. per gallon.

Fuel Oil: Furnace fuel oil, £3 12s. 6d. per ton; Diesel oil, £5 per ton.

American Oils: Best Pennsylvania crude at wells, $3·25 per barrel. Refined standard white for export in bulk, 6 cents per U.S. gallon; in barrels 12 cents. Refined water white for export in bulk, 7 cents per U.S. gallon; in barrels 13 cents.

Dividends Declared by Mining Companies

During month ended April 10.

Company	Par Value of Shares	Amount of Dividend
Ooregum Gold	Ord. 10s.	1s. 6d. less tax.
	Pref. 10s.	1s. 6d. less tax.
Pahang Consolidated	Pref. £1	3½% less tax.
Rambutan	£1	8d. less tax.
Waihi Gold	10s.	1s. tax paid.
Premier Diamond	Pref. 5s.	6s. 3d. less tax.
Aramayo de Mines en Bolivie	25fr.	5%
Gold Coast Amalgamated	£1	1s. less tax.
Rhodesia Gold Mining and Investment	10s.	9d. tax paid.
Lonely Reef	£1	15% less tax.
Union Corporation	12s. 6d.	2s. less tax.
Berenguela Tin	4s.	7½% less tax.
Hyderabad Deccan	£3	1s. less tax.

PRICES OF CHEMICALS. May 5.

These quotations are not absolute; they vary according to quantities required and contracts running.

		£	s.	d.
Acetic Acid, 40%	per cwt.	1	2	0
„ 80%	„	2	4	0
„ Glacial	per ton	54	0	0
Alum	„	14	0	0
Alumina, Sulphate	„	12	10	0
Ammonia, Anhydrous	per lb.		2	2
„ 0·880 solution	per ton	25	0	0
„ Carbonate	per lb.			4
„ Chloride, grey	per ton	37	0	0
„ „ pure	per cwt.	3	5	0
„ Nitrate	per ton	45	0	0
„ Phosphate	„	65	0	0
„ Sulphate	„	17	0	0
Antimony, Tartar Emetic	per lb.		1	6
„ Sulphide, Golden	„		1	3
Arsenic, White	per ton	37	0	0
Barium Carbonate	„	6	0	0
„ Chlorate	per lb.			7
„ Chloride	per ton	18	0	0
„ Sulphate	„	8	0	0
Benzol, 90%	per gal.		2	0
Bisulphide of Carbon	per ton	50	0	0
Bleaching Powder, 35% Cl.	„	14	0	0
„ Liquor, 7%	„	5	0	0
Borax	„	29	0	0
Boric Acid Crystals	„	60	0	0
Calcium Chloride	„	7	0	0
Carbolic Acid, crude 60%	per gal.		1	10
„ „ crystallized, 40°	per lb.			6
China Clay (at Runcorn)	per ton	4	10	0
Citric Acid	per lb.		2	1
Copper Sulphate	per ton	27	0	0
Cyanide of Sodium, 100%	per lb.			11
Hydrofluoric Acid	„			7½
Iodine	per oz.		1	0
Iron, Nitrate	per ton	8	0	0
„ Sulphate	„	3	0	0
Lead, Acetate, white	„	41	0	0
„ Nitrate	„	46	0	0
„ Oxide, Litharge	„	36	0	0
„ White	„	40	0	0
Lime, Acetate, brown	„	8	10	0
„ „ grey 80%	„	13	10	0
Magnesite, Calcined	„	20	0	0
Magnesium, Chloride	„	9	0	0
„ Sulphate	„	9	0	0
Methylated Spirit 64° Industrial	per gal.		3	0
Nitric Acid, 80° Tw.	per ton	27	0	0
Oxalic Acid	per lb.			8
Phosphoric Acid	per ton	45	0	0
Potassium Bichromate	per lb.			6½
„ Carbonate	per ton	20	0	0
„ Chlorate	per lb.			5
„ Chloride 80%	per ton	12	0	0
„ Hydrate (Caustic) 90%	„	32	0	0
„ Nitrate	„	46	0	0
„ Permanganate	per lb.			10½
„ Prussiate, Yellow	„		1	3
„ „ Red	„		4	0
„ Sulphate, 90%	per ton	15	0	0
Sodium Acetate	per ton	26	0	0
„ Arsenate 45%	„	38	0	0
„ Bicarbonate	„	11	0	0
„ Bichromate	per lb.			6
„ Carbonate (Soda Ash)	per ton	15	0	0
„ „ (Crystals)	„	6	10	0
„ Chlorate	per lb.			4
„ Hydrate, 76%	per ton	26	10	0
„ Hyposulphite	„	12	0	0
„ Nitrate, 96%	„	15	0	0
„ Phosphate	„	18	0	0
„ Prussiate	per lb.			10
„ Silicate	per ton	11	15	0
„ Sulphate (Salt-cake)	„	4	0	0
„ „ (Glauber's Salts)	„	4	0	0
„ Sulphide	„	22	0	0
„ Sulphite	„	12	10	0
Sulphur, Roll	„	10	10	0
„ Flowers	„	10	10	0
Sulphuric Acid, Fuming, 65	„	24	0	0
„ „ free from Arsenic, 144°	„	6	0	0
Superphosphate of Lime, 30%	„	4	17	6
Tartaric Acid	per lb.		1	4
Turpentine	per cwt.	4	5	9
Tin Crystals	per lb.		1	3
Titanous Chloride	„		1	0
Zinc Chloride	per ton	22	10	0
Zinc Oxide	„	40	0	0
Zinc Sulphate	„	15	0	0

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD, SILVER, DIAMONDS:	May 5, 1921 £ s. d.	May 5, 1922 £ s. d.
Rand:		
Brakpan	2 12 6	2 8 9
Central Mining (£8)	6 5 0	7 5 0
City & Suburban (£4)	3 0	2 6
City Deep	2 5 0	2 5 0
Consolidated Gold Fields	18 9	15 0
Consolidated Langlaagte	10 0	13 9
Consolidated Main Reef	10 6	11 3
Consolidated Mines Selection (10s.)	15 0	12 0
Crown Mines (10s.)	2 0 0	1 17 6
Daggafontein	3 9	3 0
Durban Roodepoort Deep	4 0	4 0
East Rand Proprietary	4 6	6 6
Ferreira Deep	9 6	7 3
Geduld	2 7 6	2 16 3
Geldenhuis Deep	5 0	5 9
Government Gold Mining Areas	4 0 0	4 5 0
Johannesburg Consolidated	1 4 0	1 5 6
Kleinfontein	5 6	6 0
Knight Central	4 3	4 6
Langlaagte Estate	11 3	13 0
Luipaards Vlei	2 0	3 0
Meyer & Charlton	4 2 6	3 7 6
Modderfontein, New (10s.)	3 5 0	3 16 3
Modderfontein B (5s.)	1 3 9	1 10 0
Modderfontein Deep (5s.)	2 5 0	2 3 9
Modderfontein East	11 3	8 6
New State Areas	1 3 9	1 8 9
Nourse	6 9	12 6
Rand Mines (5s.)	2 5 0	2 6 3
Rand Selection Corporation	2 17 6	2 7 6
Randfontein Central	9 6	11 6
Robinson (£5)	9 6	8 3
Robinson Deep A (1s.)	11 3	10 0
Rose Deep	12 3	11 9
Simmer & Jack	2 6	3 0
Springs	1 15 0	2 0 0
Sub-Nigel	12 6	12 6
Union Corporation (12s. 6d.)	16 9	18 3
Van Ryn	11 0	10 0
Van Ryn Deep	3 2 6	3 8 9
Village Deep	7 6	10 3
West Springs	12 6	8 9
Witwatersrand (Knight's)	13 9	12 6
Witwatersrand Deep	6 6	9 0
Wolhuter	4 6	3 0
Other Transvaal Gold Mines:		
Glynn's Lydenburg	6 6	12 6
Transvaal Gold Mining Estates	7 0	7 0
Diamonds in South Africa:		
De Beers Deferred (£2 10s.)	11 10 0	11 12 6
Jagersfontein	2 5 0	2 8 9
Premier Deferred (2s. 6d.)	4 10 0	4 17 6
Rhodesia:		
Cam & Motor	8 6	9 6
Chartered British South Africa	12 0	12 3
Falcon	4 6	4 0
Gaika	8 3	11 6
Globe & Phœnix (5s.)	17 6	14 6
Lonely Reef	2 0 0	2 7 6
Rezende	3 0 0	1 10 0
Shamva	1 10 0	—
West Africa:		
Abbontiakoon (10s.)	2 0	2 3
Abosso	8 0	8 6
Ashanti (4s.)	13 6	14 0
Prestea Block A	2 [illegible]	1 0
Taquah	8 0	8 6
West Australia:		
Associated Gold Mines	2 3	7 6
Associated Northern Blocks	2 6	2 3
[illegible] (5s.)	1 0	1 0
Golden Horse-Shoe (£5)	10 0	12 6
Great Boulder Proprietary (2s.)	5 0	6 0
Great Fingall (10s.)	1 6	1 0
Hampton Celebration	5 0	3 9
Hampton Properties	6 3	4 0
Ivanhoe (£5)	17 6	1 0 [illegible]
Lake View Investment (10s.)	10 0	9 0
Lake View and Star (4s.)	1 6	1 9
Oroya Links (5s.)	1 3	1 3
Sons of Gwalia	5 0	3 0
South Kalgurli (10s.)	6 6	7 0

GOLD, SILVER, cont.	May 5, 1921 £ s. d.	May 5, 1922 £ s. d.
New Zealand:		
Blackwater	2 6	5 0
Waihi	1 8 9	1 1 3
Waihi Grand Junction	7 0	7 0
America:		
Buena Tierra, Mexico	2 6	1 9
Camp Bird, Colorado	4 3	3 9
El Oro, Mexico	10 0	9 6
Esperanza, Mexico	15 6	16 0
Frontino & Bolivia, Colombia	8 9	6 3
Kirkland Lake, Ontario	11 3	17 0
Le Roi No. 2 (£5), British Columbia	2 6	2 6
Mexico Mines of El Oro, Mexico	5 5 0	3 11 3
Nechi (Pref. 10s.), Colombia	7 6	5 0
Oroville Dredging, Colombia	1 3 9	1 1 3
Plymouth Consolidated, California	17 6	7 6
St. John del Rey, Brazil	13 6	19 0
Santa Gertrudis, Mexico	6 0	8 0
Tomboy, Colorado	5 0	10 6
Russia:		
Lena Goldfields	11 3	6 3
Orsk Priority	10 0	5 0
India:		
Balaghat (10s.)	7 6	7 9
Champion Reef (2s. 6d.)	2 0	3 9
Mysore (10s.)	12 6	12 9
North Anantapur	2 6	2 6
Nundydroog (10s.)	6 0	8 9
Ooregum (10s.)	13 6	16 6
COPPER:		
Arizona Copper (5s.), Arizona	1 5 0	15 0
Cape Copper (£2), Cape and India	15 0	10 0
Esperanza, Spain	5 0	4 6
Hampden Cloncurry, Queensland	5 0	6 3
Mason & Barry, Portugal	1 15 0	2 5 0
Messina (5s.), Transvaal	4 0	3 0
Mount Elliott (£5), Queensland	10 0	12 6
Mount Lyell, Tasmania	13 0	14 9
Mount Morgan, Queensland	10 0	12 6
Namaqua (£2), Cape Province	15 0	1 12 6
Rio Tinto (£5), Spain	30 0 0	26 0 0
Russo-Asiatic Consd., Russia	8 6	9 6
Sissert, Russia	7 3	4 6
Spassky, Russia	10 0	8 9
Tanganyika, Congo and Rhodesia	1 3 9	17 6
LEAD-ZINC:		
Broken Hill:		
Amalgamated Zinc	15 0	12 6
British Broken Hill	16 3	1 3 9
Broken Hill Proprietary	1 15 0	1 3 9
Broken Hill Block 10 (£10)	10 0	8 9
Broken Hill North	1 2 6	1 10 0
Broken Hill South	1 5 0	1 10 0
Sulphide Corporation (15s.)	10 0	9 9
Zinc Corporation (10s.)	8 9	9 6
Asia:		
Burma Corporation (10 rupees)	7 6	6 0
Russian Mining	7 6	5 6
Rhodesia:		
Rhodesia Broken Hill (5s.)	7 6	5 9
TIN:		
Aramayo Mines, Bolivia	2 2 6	2 5 0
Bisichi (10s.), Nigeria	3 9	5 9
Briseis, Tasmania	2 6	3 3
Chenderiang, Malay	13 0	10 0
Dolcoath, Cornwall	6	6
East Pool (5s.), Cornwall	4 3	2 9
Ex-Lands Nigeria (2s.), Nigeria	1 6	1 6
Geevor (10s.), Cornwall	3 9	3 0
Gopeng, Malay	1 10 0	1 18 9
Ipoh Dredging, Malay	10 0	8 9
Kamunting, Malay	1 7 6	16 3
Kinta, Malay	1 10 0	1 15 0
Lahat, Malay	10 0	7 6
Malayan Tin Dredging, Malay	1 7 6	1 2 6
Mongu (10s.), Nigeria	10 0	7 6
Naraguta, Nigeria	15 0	15 0
N. N. Bauchi, Nigeria (10s.)	2 0	2 0
Pahang Consolidated (5s.), Malay	6 6	6 0
Rayfield, Nigeria	5 3	2 6
Renong Dredging, Siam	1 7 6	1 1 3
Ropp (4s.), Nigeria	6 9	5 9
Siamese Tin, Siam	2 2 6	2 0 0
South Crofty (5s.), Cornwall	6 0	5 6
Tehidy Minerals, Cornwall	8 9	7 6
Tekka, Malay	18 9	15 0
Tekka-Taiping, Malay	1 0 0	18 9
Tronoh, Malay	1 5 0	1 7 6

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

In this section we give abstracts of important articles and papers appearing in technical journals and proceedings of societies, together with brief records of other articles and papers; also notices of new books and pamphlets, lists of patents on mining and metallurgical subjects, and abstracts of the yearly reports of mining companies.

A TIMBER DROP-SHAFT LINING

The February *Bulletin* of the Canadian Institute of Mining and Metallurgy contains a paper by A. A. MacKay describing the sinking of a vertical rectangular shaft at Woodrow, Cuyuna Iron Range, Minnesota, with a drop-lining made of timber.

The accompanying illustrations show the details of the construction of the lining. This lining has an inside measurement of 8 ft. by 16 ft. The skin friction on the outside of a drop-lining often becomes so great that it is impossible to get enough weight on the unexposed portions of the shaft to overcome it. To be prepared for this emergency, the three bottom sets and the shoe were built independently and connected to the balance of the lining by ¾ by 4 in. strops so constructed that they could be easily cut, allowing the shoe to be forced ahead of the main shaft by means of jacks and wedges. A 6 ft. by $\frac{3}{16}$ in. tank steel apron was bolted to sets Nos. 1, 2, and 3, and extended three feet above set No. 3. This apron was for the purpose of keeping the sand back while the shoe was being forced downward and to give the necessary space to insert sets under set No. 4, as shown in Fig. 2. In this particular case it was not necessary to force the shoe ahead or cut the strops, as the shaft dropped two feet below the sand into the altered rock. The shaft was constructed of 12 by 12 in. Oregon fir, surfaced. It was made water-tight by placing two ribbons of oakum between each set.

The lower seven sets were 6 in. wider in dimension than the main part of the lining. Set No. 8 was 3 in. wider. This gave the lower part of the lining a bell shape. In clay or hard ground this six-inch space relieved the skin friction, while in cases of sand boils, or runs from the sides, the downward pressure on the bell-shaped section aided in carrying the lining downward. The framing was done on the surface near the shaft site. The shoe and the bell part of the lining, consisting of eight sets, were constructed and bolted together on the surface. The members of each set were tied together with 3 by 11 in. drift spikes. The sets were tied together with 1¼ in. bolts, except sets Nos. 3 and 4, which were tied together with ¾ by 4 in. strops as shown in Fig. 2. The second set of bolts from the bottom were put in after the timbers were in place. This was necessary, as the bolts had to go through the strops and the timber. A hand hole was made in set No. 3 under the bolt so that the nut could be held while being tightened. All other vertical bolts were 1¼ in. by 4 ft. 3 in., and were set with head down. The timbers were worked down on the bolts and drawn together with the nuts. The bolts were started every third set, that is, six, nine, twelve, etc. By this arrangement each set was bolted to the one above and to the one below. Steel plate washers ½ by 8 by 8 in. were used on all vertical bolts. Cast iron bridge washers were used on all other bolts. A derrick with an extra long boom, set well back from the shaft site, was used for

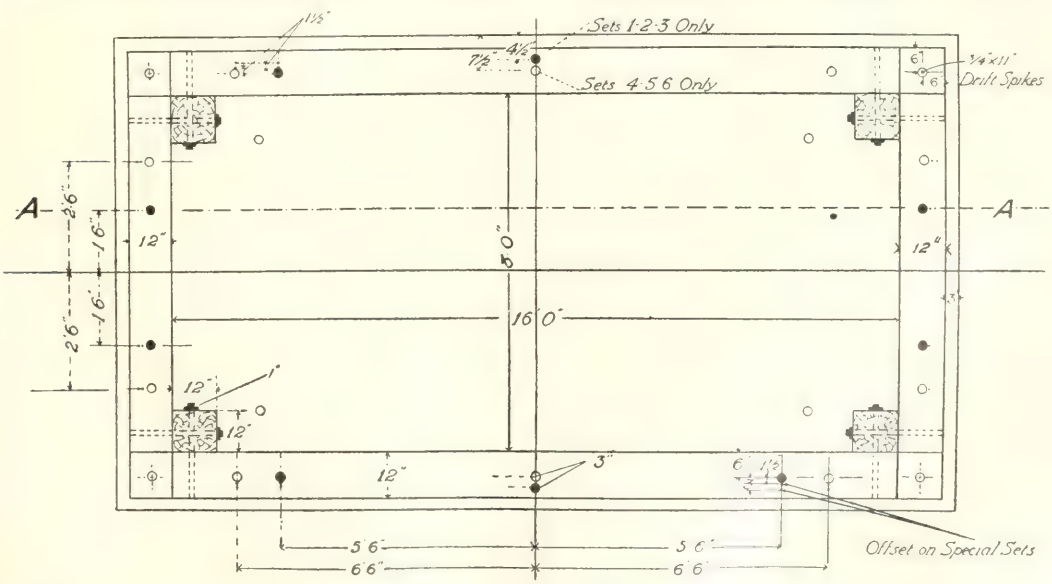


FIG. 1.—PLAN OF SETS.

hoisting. A headframe was not possible owing to the caving ground near the shaft. When the shaft was completed the ground within a radius of 30 ft. had caved to a depth of 30 ft. at the shaft. A hole 12 ft. deep was excavated at the shaft site with horse scrapers. The seven completed sets were lowered into the excavation with jacks and skids, five sets more were placed, and the forty-foot vertical corner members placed with the derrick and bolted to the twelve sets. Concrete was poured into the spaces between the corner members, which gave extra stiffness to the shaft.

two weeks, the pumps would have to be packed every hour, and new valves were necessary every day. The end of the suction hose and screen could be raised and lowered by means of rope and blocks. In case of a sand boil, one miner would stand by to keep the hose from getting choked or buried in the sand.

The pipe lines were carried as shown in Fig. 3. The pipe was cut in 10 ft. lengths, flanged at both ends and added at the top of the lining as the latter dropped. The variation in height and length was taken care of by a swivel joint made with two

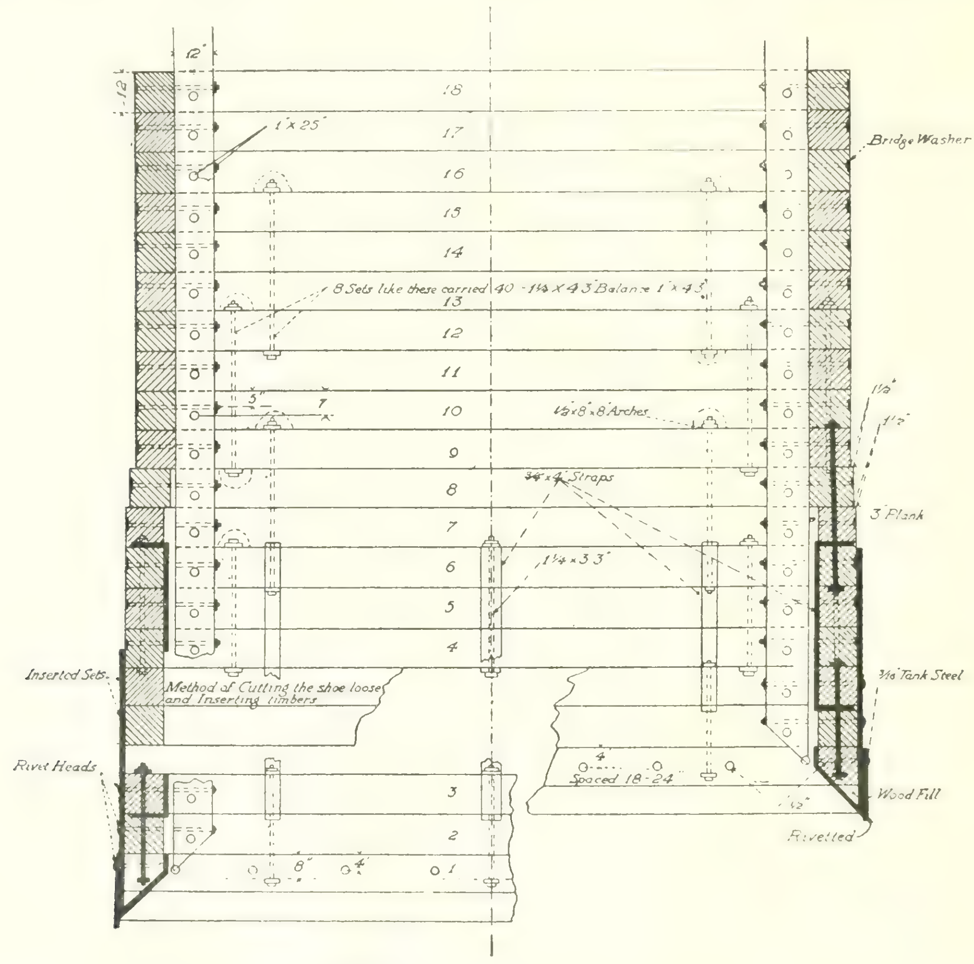


FIG. 2.—VERTICAL SECTION OF LINING.

The miners started to dig in the shaft on April 6, 1921. At a depth of 16 ft. water was encountered and digging was stopped while enough sets were added to place the pumps in safety. The pumps, two No. 10 Camerons, bored and bushed, were placed 20 ft. above the lower set. Owing to the sand boils it was necessary to have the pumps as high as practicable in the shaft. The pumps had been bushed with phosphor-bronze bushings. This was necessary on account of the extreme wear caused by the sand. Extra bushings were kept on hand and could be installed rapidly. When sinking through the fine sand the bushings would last about

L's. The average flow of water was about 300 gallons per minute. One of the pumps could take care of this flow, thus allowing time to add pipes and pack pumps, etc.

When possible, the miners would dig under the cutting edge of the shoe, but the greater part of the time the sand in the shaft was from 2 to 6 ft. above the cutting edge, and in very fine sand up to 15 ft. above the cutting edge. At such times the sand would be shovelled from the centre when the shaft was dropping vertically, or from the sides when it was desired to start a sand run from one side or the other in order to bring the lining back into a

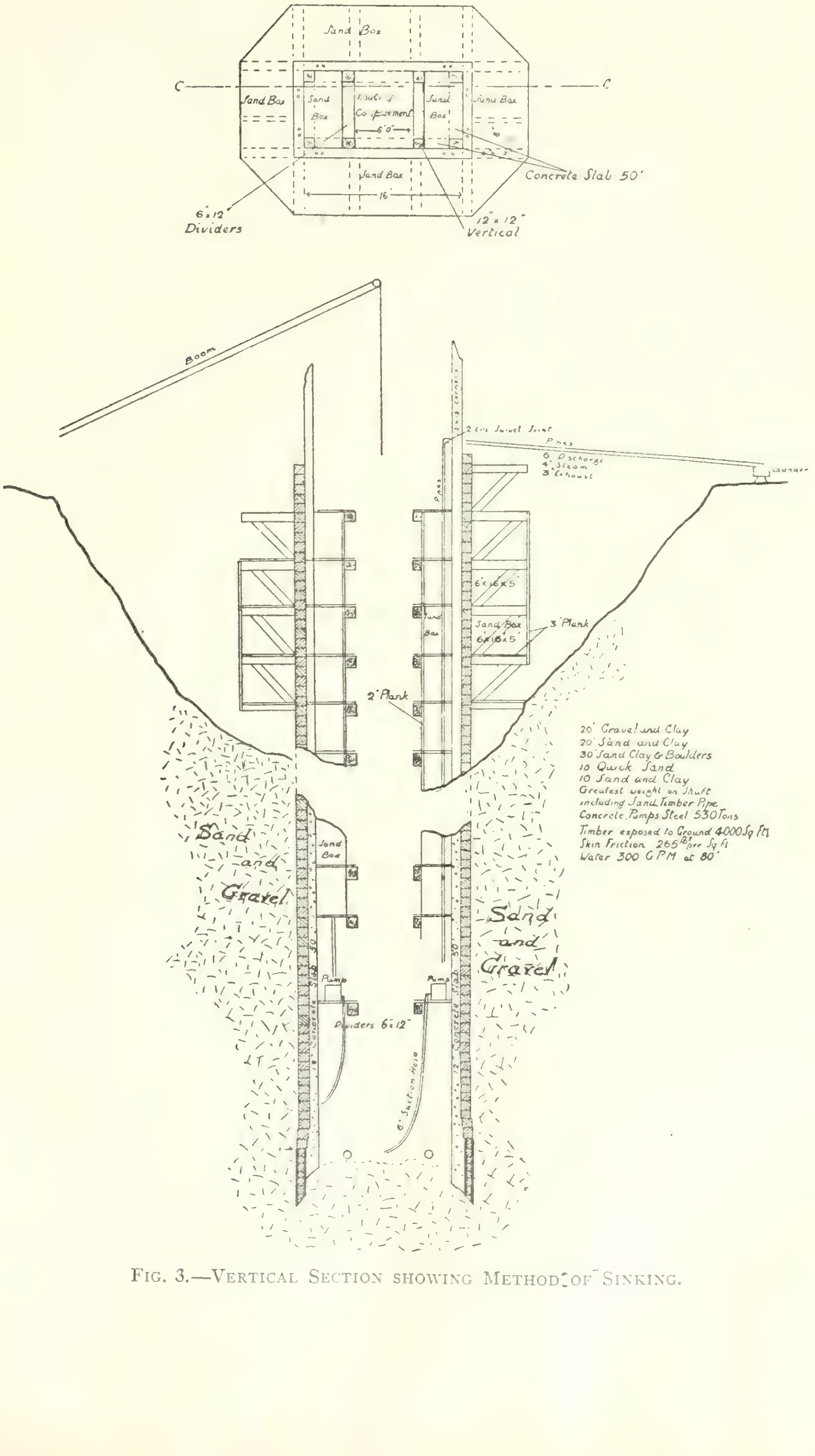


FIG. 3.—VERTICAL SECTION SHOWING METHOD OF SINKING.

vertical plane. Small sand boils could generally be checked by piling cement sacks filled with sand on the boiling area, and by driving oak planks past the shoe. However, the only sure way of stopping sand boils was to have weight enough on the shaft to carry it downward during the boil and thus automatically shut it out. The downward pressure against the projecting shoe during a boil aided materially in carrying the shaft down. During heavy boils the shaft would at times drop as much as 6 in. in a few minutes. The shift-bosses and miners watched the plumb-bobs which were kept suspended from the top to see that the shaft did not get out of line or out of a vertical plane.

The chief sources of weight on the shaft were timbers, bolts, steel, pumps, pipe, concrete, and sand. The sand boxes were started at set No. 30. The interior sand boxes were 5 ft. high by 4 ft. wide by 8 ft. long, and were continuous to the top. This gave 64 cu. ft. of sand to the foot in height. When the shaft was completed there was 60 ft. of sand boxes containing 3,840 cu. ft. of sand. The outside boxes were started when the shaft was down 50 ft. These boxes were generally carried 20 ft. high and consisted of four independent boxes, one above the other. When the lining dropped to where the lower boxes touched the ground these boxes were removed and others added at the top to take their place. The outside boxes contained about 5,360 cu. ft. of sand.

When the shoe was passing through clay and boulders much trouble was caused by boulders getting under the cutting edge of the shoe. In such cases the cutting edge was generally in sight and the boulders could be worked through into the shaft. The largest boulder encountered was 3 ft. in diameter. After passing through 70 ft. of stratified material, consisting of layers of gravel, clay, sand, boulders, and clay, and sand and clay, successively, in beds from 2 to 10 ft. thick, the lining went through 10 ft. of quicksand, 10 ft. of fine sand and clay, and 2 ft. of altered slate.

When the shoe was passing through the quicksand the more compact material above settled against the walls of the shaft causing a heavy drag. The sticky clay increased the skin friction very much. The upper 4 ft. of the underlying rock was very soft and had the appearance of soft clay. The altered rock made a very good seal, shutting out all the water and sand. Before the seal could be strengthened with concrete on the inside and outside of the shoe, the sand and water broke through in a small hole about 6 in. in diameter and filled the shaft with sand to within 30 ft. of the top, covering the pumps and all the tools. This sand was shovelled out in about four days. The hole under the shoe was found sealed with boulders and clay. The shoe was cemented in and no more trouble encountered. The weight was taken off on July 1. The lining dropped on an average of 1 ft. per day. When completed, it had a 9 in. bow in the centre. The lower edge of the shoe was vertically under the top of the shaft. The rock shaft was started in the proper line under the shoe. After sinking in the rock for 15 ft. it was found to be hard enough to hold bearers for the lining above.

The miners and pumpmen worked in eight hour shifts. The balance of the men worked ten and twelve hour shifts. The force list included 3 shift-bosses, 12 miners, 3 pumpmen, 2 bucket tenders, 2 hoist and firemen, 1 mechanic, 1 blacksmith, 1 blacksmith helper, 3 carpenters, 1 carpenter helper, and 1 timekeeper.

The greatest weight on the shaft at any time was 530 tons. The greatest amount of skin friction was approximately 265 pounds per square foot.

OPEN-STOPE SYSTEM OF MINING AT SPIES MINE

In *Mining and Metallurgy* for March, S. R. Elliott gives an account of the open-stope system of mining employed at the Spies iron mine near the village of Iron River, Michigan, which is operated by the Cleveland Cliffs Iron Company.

The jasper hanging walls of most of the deposits in the Iron River district dip at a steep angle and are strong, standing without caving, even after mining has been continued for years and after large excavations have been made. The ore is hard and tough and contains no slippage faces. It occurs in large masses, often egg-shaped, with the smaller end down. It can be mined in open stopes without the use of timber. The Spies system was developed to utilize the advantages of the open-stope method and to avoid the disadvantages of the shrinkage stope.

The Spies shaft was sunk to such a depth that the bottom, or third level, was in rock at a short distance below the bottom of the ore-body, the shape and extent of which had been previously determined by diamond-drilling.

In order to provide the necessary mills and rises, three parallel cross-cuts were driven on 25 ft. centres on the bottom level. Drifts on the second and first levels were driven to the ore-body and followed the foot-wall in a southerly direction to the end of the ore. In cross-cut 3, Fig. 1, rises 30, 40, 50, and 60 were carried up on the foot-wall and holed into the second level, and ultimately carried up and holed into the first level. These foot-wall rises carry the pipes and ladders, provide a means of ventilation, and furnish safe communication to all working places in the stope.

From cross-cuts 1, 2, and 3, rises were completed to a height of 32 ft., or the elevation of the first sub-level. They were then connected by east and west cross-cuts to the main foot-wall rises 30, 40, 50, and 60, shown in Fig. 4. The cross-cuts in rises 1 to 5 were then driven west, and the hanging wall located. While this work was in progress, rises 1 to 5, 10, 12, 14, 16, 18 were driven until they reached the hanging wall. At intervals of 22 ft., the rises were connected by east and west cross-cuts and the hanging wall to the west was located at the elevation of each sub-level. This is shown in Fig. 2.

Below the 639 ft. sub-level rises 1 to 5 were coned to an angle of about 45° to serve as mills. Miners then started in each cross-cut on the 639 ft. sub-level, at points near the hanging wall, and made fan-shaped holes toward the same. By repeating this operation on sub-levels at higher elevations, the ore was cut away from the hanging wall and a narrow opening existed over the mills in cross-cut 1 for the length and height of the ore-body. From this time on, to the completion of the stope, the work was straight mining. Miners set up their machines in the various cross-cuts at a safe distance from the edge of the open stope, and drove holes pointed fan-wise towards the west, care being taken to pull back the east face in a vertical plane.

If one could stand against the hanging wall at a point opposite the centre of the stope and look east, this face would resemble, in perspective, a number of pyramid-shaped funnels in a horizontal position, the larger end pointing toward the observer, the cross-cuts being the spouts. This is shown in section and elevation in Figs. 5 and 6. While stoping is being continued, it is necessary to complete additional rises and to do cross-cutting at higher elevations, or in parts of the ore-body farther east.

The author then discusses the disadvantages of the shrinkage stope :—

(1) In a shrinkage stope, after mills have been made, the ore-body is undercut. By setting up the machines on the broken ore and working around the perimeter of the stope, its height is increased until the top of the deposit is reached. After each blast only sufficient ore is drawn from the mills to make room for the miners to work. A safe rule to follow is to have the back above the point where the machines are set up close enough for it to be touched by a miner when his arm is extended. With this precaution, it can be readily trimmed. Further, miners should not be permitted to go out toward the centre of the stope, but should be kept close to a solid wall. Observing these rules, and always working around the perimeter, causes large ore-bodies to remain in the centre of the stope which either must be blasted, by the use of long drills, or if they cannot be reached, must be left until they become so heavy that they will fall of their weight. In time, these large masses are drawn down to the mills, when they must be broken by men who enter the mills from the bottom to drill and blast them ; this is slow, expensive, and exceedingly dangerous work.

(2) As the ore is broken in a shrinkage stope, only about one-third of it can be drawn out of the mills. The pile in the stope must constantly be increased in height until the top of the deposit has been reached and the stope completed. A large investment, represented by two-thirds of the broken ore, is tied up until the stope is completed.

(3) The miners spend a large proportion of their time trimming the back, trying to make it safe ; their drilling efficiency is, therefore, low.

(4) In drawing sufficient ore each day to keep the top of the pile at the proper distance from the back, there is constant danger that the ore will not settle properly and later on will surge and endanger the lives of the men in the stope.

(5) If seams or bunches of rock are encountered they must be broken with the ore ; there is no means of separating the material.

(6) Ventilation as a rule is poor, and much time is lost after each blast.

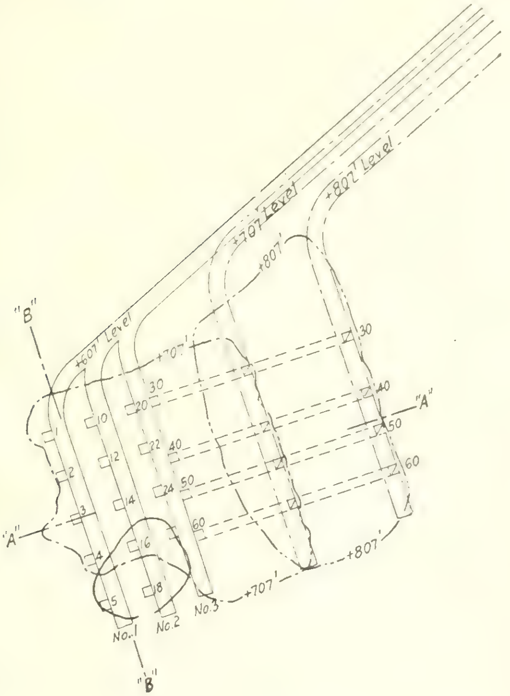


FIG. 1.—PLAN OF SPIES MINE.

FIG. 2.

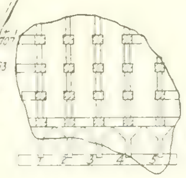


FIG. 3.

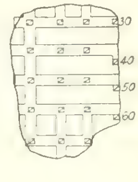


FIG. 4.

FIG. 5.

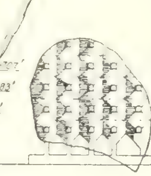


FIG. 6.

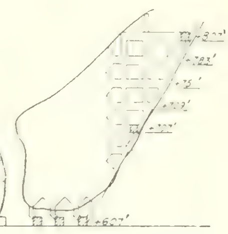


FIG. 7.

Against the foregoing disadvantages the author contrasts the advantages of the Spies system.

(1) All men are provided with a safe and easy travelling road to their working places. There is every opportunity for miners to drill their holes with a proper burden on them, so that it is unnecessary to break the ore in large masses. It is not necessary to go up into mills to drill and blast. These are the chief factors that make it possible to obtain low cost by the use of this system.

(2) All of the ore broken each day is drawn from the mills, only enough being left to protect the stopers from the shock of falling ore blasted in the stope. An accurate check can, therefore, be kept on the miners and high efficiency obtained.

(3) No time is lost in trimming. The men are in no danger from falls of ground so their time is spent

in drilling and blasting; their efficiency, therefore, is much higher than in the shrinkage stope.

(4) There is no danger that the ore upon which the men are standing will be drawn from under their feet as they work in cross-cuts with solid ore below them. Their machines are set up on posts, which is preferable to using tripods on loose ground.

(5) During the development work in the sub-levels all seams of rock in the ore are outlined and can be mined before the stope has reached that locality, the rock being dumped into rises that are not being used as mills. It is possible, therefore, to mine the ore and keep it clean.

(6) On account of the large number of small rises and the connexions with upper levels, no trouble is experienced with ventilation. Blasting can be done at any time during the shift, and only a few minutes lost. The area of the open stope soon becomes so large that the gases are rapidly dissipated and pass off through the upper levels.

The author also discusses relative costs.

GEOLOGY OF THE BRADEN COPPER MINE, CHILE

In *Economic Geology* for April, Waldemar Lindgren and Edson S. Bastin describe the geology of the Braden copper mine, Chile, and give their interpretation of the history of the formation of the rocks and ore deposits. It may be preliminarily mentioned that the proved ore is estimated at 175,000,000 tons, averaging 2·45% copper, and that during 1920 the daily average of ore treated was over 6,000 tons containing 2·08% copper, from which 32,459 tons of copper was produced.

The Braden mine seems to be the unique example of a copper deposit lying in and about a large explosive volcanic vent. It furnishes one of the most striking evidences on record of the intimate connexion in origin between certain mineralizing solutions and bodies of igneous rocks; for, in the Braden crater, rising mineralizing solutions and ascending masses of igneous rock followed the same paths and alternated with each other. The geologic history comprises three periods of igneous intrusion, three periods of mineralization by ascending solutions, uplift, and tilting of the land, erosion of the surface, and enrichment of the ores by waters descending from the surface, and other events.

The Braden mine or El Mineral Teniente, as the Chileans call it, is situated in the Western Cordillera of Chile, 30 miles north-east of Rancagua, a town a couple of hours' ride by train south of Santiago. It lies on the south slope of the upper valley of the Teniente River, a small tributary of the Coya, which again empties into the Cachapoal River. The railroad from Rancagua leads steadily upwards following the torrential streams till the mine is reached. The slopes are covered by brush and small trees within a few miles of the mine; beyond this there is little or no vegetation, and the whole region becomes Alpine in aspect, with plenty of evidence of a former glaciation. At the mine the elevations range from 7,458 to 9,642 ft., and a few miles east of the mine the divide is reached at an elevation of 11,800 ft. Beyond this lies the longitudinal valley of the Maipu, beyond which, 28 miles from the mine, rises the main snow-covered divide of the Western Cordillera with elevations of up to 18,000 ft. Up to within two miles of the mine the range is built of Tertiary effusive rocks, alternating with tuffs and tuff breccias.

The first event recorded in the rocks of the vicinity of the Braden mine is the eruption of a great series of volcanic rocks now forming the rudely bedded series of Cerro Negro, the Caletones cliffs, and the valley of Puquios. The writers have termed these the "Cerro Negro Series." The volcanic mountains, probably several in number, from which these rocks were erupted have been so dissected by stream erosion that detailed geological studies covering large areas would be needed to discover even their whereabouts. The rocks of this series are all products of volcanic eruption; flows or sheets of lava poured out upon the surface from volcanic vents, alternating with tuffs or beds of lava fragments showered down during the eruptions. In age they are probably Tertiary, and they constitute the oldest known formation of the district, antedating the formation of the Braden crater and of the ore deposits. Mineralization of the series is mainly confined to scattered veins of negligible commercial importance, some of which were formed prior to the main mineralization of the Braden mine, while others may be contemporaneous with it.

Into this volcanic series there was later forced from below a great mass of molten rock which displaced and pried apart the beds of the older rock and solidified to form andesite porphyry, where it cooled rapidly, and quartz diorites, where its cooling was more leisurely. Complete gradations are traceable from the andesite porphyries into quartz diorites. These two types of rock are similar in mineral and chemical composition, and their difference in name is chiefly a matter of texture. Because the andesite porphyries are more abundant than the quartz diorites in the mine workings, and because the name andesite has long been applied to these rocks in the company reports, it is best to use "Intrusive Andesite Porphyry" as a comprehensive name for the formation.

The series constitutes a belt from about 1·5 to 5·5 kilometres wide, which has been traced from the so-called Gypsum mine north-east of the crater to the Caletones cliffs, as is shown in Fig. 1. The further extent of these rocks north-east and south-west is not known. They are bounded on the north-west and south-east by the surface volcanic rocks of the Cerro Negro Series.

At its borders the andesite-diorite mass sends off wedge-like branches or sills which split apart the beds of the bordering Cerro Negro Series. These branches can be clearly traced into continuity with the main body of andesite-diorite, and are similar to it in composition. These relations can be best seen near the divide between Canyon Diablo and the Puquios Valley, and less perfectly in the cliffs at Caletones, and they show that the andesite porphyries and quartz diorites are intrusive rocks, or, in other words, were forced from below in a molten condition into the older rocks of the Cerro Negro Series. Their intrusive origin is further demonstrated by their coarseness of grain in many localities, a feature indicative of comparatively slow cooling under a cover of other rocks.

While showing variations in coarseness and local brecciation, the rocks of the Intrusive Andesite Porphyry Series do not show flow lines, spherulites, amygdaloidal structure, or other features characteristic of surface volcanic rocks, and no tuffs are interbedded with them. In these respects they contrast greatly with the bordering Cerro Negro Series.

During the earth movements that were gradually uplifting the Cordillera region the intrusive andesite porphyry mass that has just been described became fractured, bleached, and tourmalinized over considerable areas and locally slightly mineralized with pyrite. The andesite porphyries and quartz diorites have in many places been so completely altered that their original character can only be

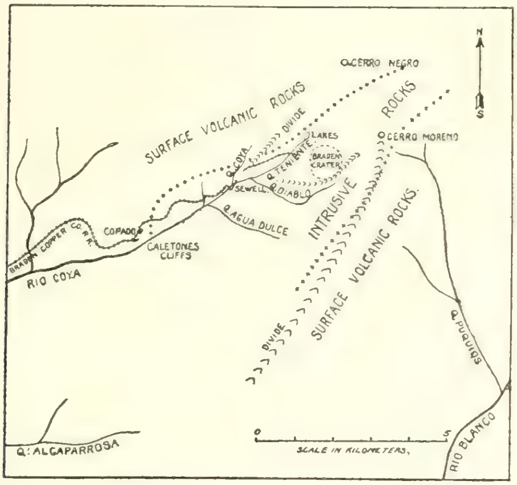


FIG. 1.—MAP SHOWING THE POSITION OF THE BRADEN CRATER AND THE LIMITS OF THE INTRUSIVE ANDESITE PORPHYRY-QUARTZ DIORITE.

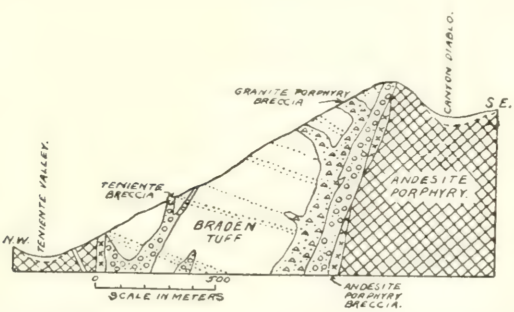


FIG. 3.—GENERALIZED CROSS SECTION OF THE BRADEN CRATER TO-DAY, after (1) a second intrusion of the igneous rocks from beneath the crater to higher levels than before, (2) tilting of the land to the southwest, and (3) lowering of the surface by erosion. The position of this section with respect to the earlier stage in crater development is indicated by the broken lines A–A in Fig. 2.

proved by gradations from the altered into the fresh types. This alteration was accompanied by sparse deposition of sulphides and constitutes the first period of mineralization. The earliest alteration consists in the development of magnetite in dark, cloudlike masses and of disseminated dirty brown small foils of biotite. The rock then becomes strongly chloritized, with more or less sericite, both attacking the dark silicates and the felspars. The groundmass is more or less silicified; sometimes it is converted into a mosaic of small quartz grains. Rutile is abundant in many sections. Lastly tourmaline develops, replacing all the other secondary minerals as well as the felspars.

The quartz veins of the mine and its vicinity appear to be another phase of the first

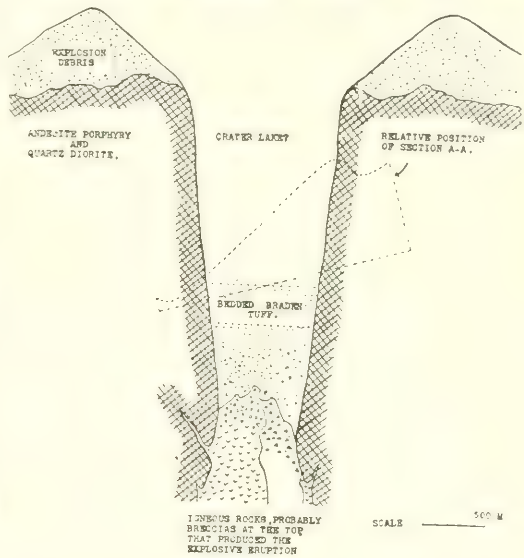


FIG. 2.—IDEALIZED RECONSTRUCTION OF THE BRADEN CRATER not long after the explosion when some of the debris from the explosion had fallen back and had been washed back into the vent. Bedding in some of the Braden tuff suggests that a lake occupied the vent at this period.

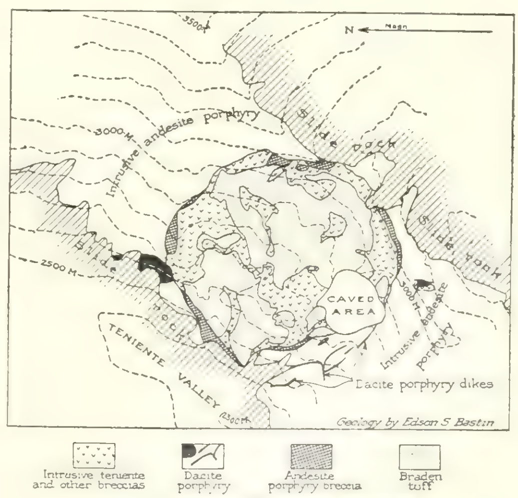


FIG. 4.—GEOLOGICAL MAP OF THE BRADEN MINE.

mineralization. They range in width from a few centimetres to 5 or 6 metres, and commonly have north to north-east strikes and steep dips. On the surface, notably in the vicinity of Fortuna No. 2 gulch, they stand up like ragged rusty walls above the surface of the bordering andesite porphyry-

A few consist wholly of white quartz, but in the majority black tourmaline, pyrite, and chalcopyrite are present. Nowhere were the sulphides of this mineralization deposited in sufficient abundance to form ore.

The event of supreme importance in the geologic history of the mine was the great explosion which produced a volcanic vent and shattered the bordering andesite porphyry in such a manner as to provide ample open spaces for the deposition, somewhat later, of ore minerals. This explosion was probably caused by the upward progress of a body of molten and partly molten rock beneath the present vent. A sudden upward pulsation of this hot mass, bringing it into contact with portions of the andesite-diorite mass that lay nearer to the surface and whose fractures were filled with ground water, and the violent conversion of this water into steam was the probable cause of the explosive eruption. The gases imprisoned in the magma itself were probably a co-operating factor in the explosion. The vent produced was certainly more than 1,000 metres in depth, and probably nearer 2,000 metres, and about 1,000 metres in average width, tapering somewhat from top to bottom. The material erupted consisted mainly of fragments of the andesite porphyry mass that formed the crater walls mingled with smaller numbers of fragments of alkali porphyries that apparently represent the upper parts of the intrusive mass that produced the explosion and were shattered by it (Fig. 4).

The eruption appears to have been solely an explosive shattering of rocks already solidified. No molten or partly molten rock was ejected from the vent as lava flows or showers of pumice, and it is probable that steam was the principal gas given off. The debris of the eruption in part fell back into the vent filling its lower portion, but most of it was probably strewn over the surface bordering the crater mouth (Fig. 2).

Next ensued a period of quiescence as regards eruptive activity, during which surface processes assumed the leading rôle in the development of the geology of the mine. There are evidences that at this time the depression produced by the explosion became converted into a lake, while at the same time rains and freshets gradually washed back into the hole part of the debris which the eruption had strewn over the surface. During its redeposition within the vent much of this debris acquired a bedded structure ; beds of fine material alternating with coarse fragments, and many of the fragments became partially rounded ; in fact, the evidence of the existence of a lake consists in this bedding and the rounding of the fragments. This filling constitutes the Braden tuff, of which a thickness of approximately 800 metres is now in view between the highest exposures in the upper part of the crater and the lowest exposures in the deepest mine workings (Fig. 3). At the close of these events there existed a cylindrical body of Braden tuff, filling the crater and bordered by fractured andesite porphyry. These rocks extended farther upward than their present exposures, for they have subsequently been cut down by erosion to an unknown but probably considerable extent. It is also probable that they were at this time buried under other rocks whose character is unknown, for the rocks and ore minerals which in the events next to be described were brought into the position of the present Braden mine lack the features usually found in ore and rocks crystallized at or close to the surface.

The explosive eruption which formed the Braden vent greatly shattered the andesite porphyry composing its periphery. The shattering, as might be expected, was exceedingly irregular, fracture planes trending in every conceivable direction, though in a few localities a predominant trend, parallel to the crater wall, is discernible. The width of the zone of most intense shattering is uneven, ranging from 100 and 200 metres to more than 600 metres, the widest portions being on the north-east side of the crater. After the interval, during which the crater became filled with the Braden tuffs, mineralizing solutions, rising principally about the periphery of the old vent, deposited quartz, tourmaline, biotite, pyrite, and chalcopyrite in irregular fractures in the andesite porphyry and formed large bodies of mineralized material with a copper content in most places of between 0·5 and 1·5%, though locally slightly richer. Thus was initiated the formation of the great ore-bodies that are the main resource of the Braden mine, but, as later explained, their enrichment by descending secondary mineralization was necessary to raise their copper content to a workable grade.

Although the Braden tuffs certainly occupy the vent of the old crater at the time of this mineralization, they were almost nowhere mineralized to the extent of more than 0·5% of copper. That they were penetrated by the mineralizing solutions is shown by the almost universal presence in them of scattered fine grains of pyrite and chalcopyrite, but because of their somewhat clayey matrix, and the nearly complete absence of fracture planes, they were not a favourable locus for ore deposition.

The ores of the second period are andesite porphyry traversed by veinlets of ore minerals from a millimetre or less up to a centimetre, or rarely 2 or 3 centimetres in width. Within the ore-bodies there are seldom less than a dozen such veinlets in a metre's length of andesite porphyry. Between the veinlets the andesite porpyhry commonly carries scattered small grains of sulphides, but more than 90% of the copper is undoubtedly in the veinlets. The ores commonly break readily into small blocks along the sulphide veinlets, a characteristic favouring cheap mining. The predominant ore minerals of this period are quartz, pyrite, and chalcopyrite ; black tourmaline, though nearly universally present, is subordinate in amount ; biotite was noted only in a few places and in very minor amounts, but was clearly contemporaneous with the sulphides. The relative abundance of the three principal minerals varies considerably even in adjacent veinlets ; quartz is abundant in some and almost absent from others ; pyrite is the dominant sulphide in some and chalcopyrite in others. Commonly the several ore minerals are irregularly associated, but in some veinlets the quartz is mostly next to the walls and the sulphides in the centre. Of much economic importance is the tendency for pyrite to increase and for chalcopyrite to decrease in relative abundance outward in all directions from the periphery of the crater. In many of the cross-cuts into the foot-wall the passage from ore to material below workable grade is practically coincident with the transition from predominant chalcopyrite (somewhat enriched) to predominant pyrite.

The next event in the complex history was the intrusion of masses of molten rock which crystallized as dykes and irregular bodies of dacite porphyry, and of bodies of partly or wholly solidified and brecciated dacite and latite porphyries, giving rise to what has been termed the Teniente breccia. These intrusive masses are confined, so far as known, to the crater or its near vicinity. The Teniente breccia forms a nearly continuous sheath between the filling of Braden tuff and the andesite porphyry of the crater walls, sending off, however, irregular ramifications into the central portions of the tuff mass. A single outlying body of Teniente breccia occurs in the andesite porphyry shortly south of the vent near the divide between Teniente valley and Canyon Diablo. The intrusions probably constituted a second and higher upsurging of molten and partly molten rock from the same source as that which produced the eruption. That a second explosion did not result is possibly due to the fact that this intrusion, unlike the first, did not come in contact with cool, wet rocks, being preceded by mineralizing solutions, which heated the rocks through which they passed and sealed with ore minerals fractures previously occupied by ground water.

As explained the Teniente breccias were, in the main, masses of rock fragments forced upward by the pressure of partly molten and molten rocks below. In their upward progress they exerted a considerable friction on the andesite porphyry of the walls of the vent. Although the fractures in that porphyry had been partly sealed by sulphides during the second mineralization, it was still a weak body of rock, and large masses of it were intimately brecciated during the intrusion of the breccia. In this manner were formed the bodies of andesite porphyry breccia which characterize the periphery of the vent, and which normally lie between Teniente breccia and massive andesite porphyry, although in some localities Teniente breccia has been forced between the two into direct contact with massive andesite porphyry, as on the east side of the vent.

The next event in the geologic history of the mine was renewed mineralization in which the peripheral portion of the filled vent again formed a channel for the upward passage of copper-bearing solutions. These solutions rarely deposited tourmaline, but, on the contrary, dissolved it, locally bleaching the tourmaline-bearing breccias, taking tourmaline into solution and depositing various other minerals in its place. In this respect they contrasted with the tourmalinizing solutions of the main period of primary mineralization and with the solutions of the preceding tourmalinizing period. This poverty in tourmaline probably indicates that the solutions were not so hot as those that preceded, and it may be inferred that some little time, during which cooling of the rocks was in progress, elapsed between tourmalinizing of the Teniente breccia and this mineralization. This third mineralization was much less extensive than the second or main mineralization, but its ores were richer and characterized by a much greater variety of minerals. Most of the spectacular ores of the mine and those first worked by the Spaniards belonged to this period. A few moderate-sized bodies of ore were formed, the bornite ore-body being an example, but many of the ore-bodies are too small to be of much value. In places the copper content of the earlier formed main ore-bodies was increased by additions of sulphides at this period.

The sealing of the fractures in the andesite porphyry by sulphides of the second period, and the sealing of the pores of the various breccias by tourmaline resulted in confining the active circulation of the later solutions mainly to scattered zones of fracturing formed since the second mineralization. Open spaces being now comparatively rare, it became necessary for the mineralizing solutions in many places to dissolve tourmaline or rock minerals to provide space for the deposition of sulphides or other ore minerals, a process well understood by students of ore deposits under the name replacement.

A fourth phase of mineralization may be recognized, during which the temperature was still further lowered. It represents the last dying efforts of the mineralizing solutions. This deposition is local, and took place only in open cavities where chalcopyrite and bornite were found in small amounts, together with small crystals of barite and quartz, and wonderfully large crystals of gypsum.

In the further history of the Braden mine, tilting and uplift of the land, erosion of the surface by streams and the action of the air and surface waters upon the ores assumed the leading roles. At some period, not definitely known but subsequent to all the events that have been described, the whole region about the Braden mine was tilted and probably uplifted, so that the volcanic rocks of the Cerro Negro Series and the Braden tuffs, deposited in a nearly horizontal position, assumed their present attitude with gentle dips at 15 to 20° to the southeast. At this time there were present around the periphery of the old vent large bodies of rock mineralized to the extent of approximately 1 to 1·25% copper, and a few small bodies much more highly mineralized. Further mineralization was necessary to form large bodies of workable ore, and this mineralization was accomplished by the action of the air and of the surface waters on the primary ore, the process commonly known as secondary enrichment, or downward enrichment. From the close of the last period of primary mineralization to the present day the country about the crater has been continuously subjected to gradual wearing down of the surface through the fracturing and disintegration of the rocks by temperature changes and by snow and ice. Glaciers and streams carried away the debris. As soon as these processes had brought the surface down to the copper-bearing rocks, the combined action of the air and of waters of surface origin led to the oxidation of the copper-bearing sulphides and the taking into solution, mainly as copper sulphate, of much of the copper. Some of the copper remained in the near-surface oxidized zone as cuprite, chrysocolla, and other oxidized copper minerals; but much of it was carried downward in solution and redeposited as chalcocite where these solutions came in contact with primary pyrite and chalcopyrite, the latter being always more easily replaced. The chalcocite replaced the chalcopyrite and pyrite volume for volume, and since it carries approximately 80% of copper as against 34·5 % in chalcopyrite, and none in pyrite, the process resulted in notable enrichment, bringing the large bodies of 1 to 1·25 % material formed during the main primary mineralization up to 1·5 to 4 % or even higher in copper and rendering them commercially workable.

Chalcocite is the only secondary copper sulphide present in important amounts in the zone of chalcocite enrichment, although covellite and bornite were noted. The development of chalcocite is greatest in the upper part of the enriched zone, and gradually decreases in depth. In the upper part of the zone, chalcopyrite has, in a few places, been almost completely replaced by chalcocite, and pyrite replaced to a lesser degree; commonly only a thin outer layer of the pyrite is affected. In the lower part of the zone, chalcocite commonly forms thin films along every fracture, however small, in the chalcopyrite, but pyrite appears to be unaffected.

The ore-bodies of the Braden mine are commonly heavily oxidized and leached of a large share of their copper to depths of from 50 to 100 metres. An important characteristic of the oxidation is its local extension downward in tooth-like form to greater depths. The largest of these areas of deep oxidation lies beneath one of the principal minor valleys excavated in the volcanic vent. In most of the workings which expose highly oxidized materials there are very abrupt transitions from highly leached material with a copper content of less than 1·5 % or even less than 0·5 % to ores rich in sulphides and assaying over 2·5 % and in places over 3·5 % copper. These are in some places concomitant with the passage from breccias to massive rock, or from one kind of breccia to another, and in such places are clearly influenced by marked differences in the perviousness of the various formations to the air and oxidizing waters. In other places, transitions equally abrupt take place wholly within massive andesite porphyry and are not accompanied by conspicuous differences in porosity. In the latter cases, especially, the abrupt transitions without the intervention of zones rich in oxidized copper minerals, and the deep extension of teeth of oxidized material to the very bottom of the zone of chalcocite enrichment, is indicative of the downward progress of oxidation at a more rapid rate than chalcocite enrichment. The phenomena of oxidation, therefore, as well as the topographic features, and the relations of the lower limit of chalcocite enrichment to the ground-water level all agree in indicating that the region in which the mine is located has undergone comparatively recent uplift. The uplift acted as a stimulus to erosion by increasing the grade of the streams; it stimulated oxidation by increasing the distance between the surface and the ground water level and thus exposing new thicknesses of material to oxidation; it also stimulated chalcocite enrichment, but as this is a slow process the downward movement of the chalcocite zone since the uplift has been slight. The oxidized zone has come as a consequence to overlap the zone of chalcocite enrichment instead of lying uniformly above it, and teeth of highly leached and oxidized material have come to penetrate nearly to the bottom of the chalcocite zone between walls of rich and little oxidized chalcocite ore.

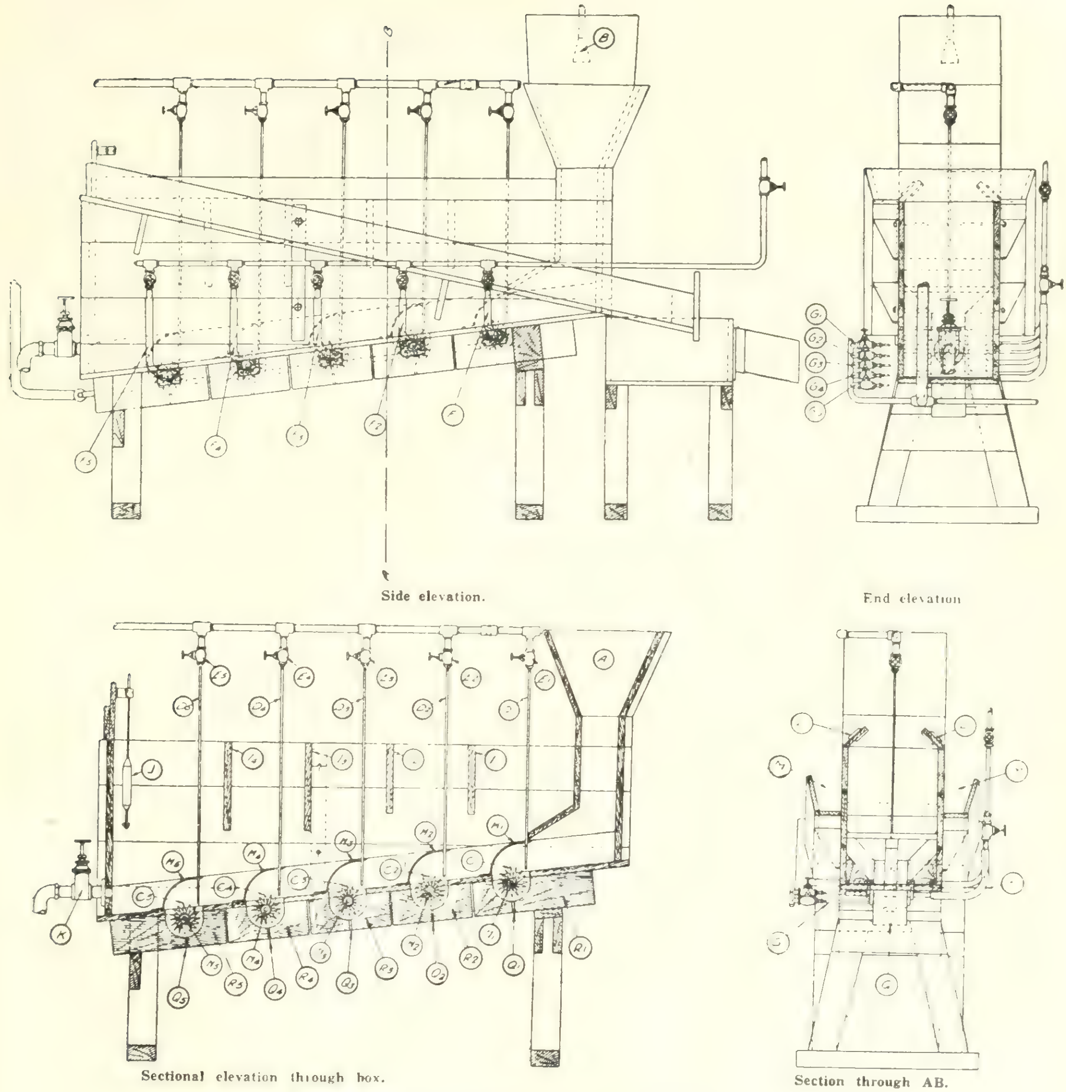
Flotation Machine at Mount Lyell.—*Chemical Engineering and Mining Review* for February describes a concentrator applied at the Mount Lyell copper mine, Tasmania, for reducing the siliceous content of Minerals Separation concentrates. It has also been applied to the primary flotation of the sulphide ores. The machine is the invention of N. H. Wood and S. J. Harry, members of the Mount Lyell staff.

The machine comprises a feed chute A, with a water-spray B, open at the top and hopper-shaped. The feed discharges from the chute towards atomizing wheels C_1, C_2, C_3, C_4, C_5, which are in series. The wheels are driven by high-pressure water jets D_1, etc., and the speed can be controlled by the valves F_1, etc. The high-pressure water is injected into spindles F_1, etc. The low-pressure air is led into atomizing wheels by pipes G_1, etc., and is regulated by ordinary globe valves. Above the atomizing wheels are iron mantles H_1, etc. Above the mantles are movable wooden baffles I_1, I_2, I_3, I_4. J is a float indicator which shows the operator the depth of the froth required. Residues are removed from the bottom of the machine by the valve or spigot K. The movable crowding boards L, situated at the top of the box, may be lengthened or shortened, as required; the overflow is discharged into the launders M. The spindles N_1, etc., are kept in position by glands O and stuffing-boxes P. Drain vents are situated under each wheel Q_1, etc. R_1, etc., are cells for the atomizing wheels, held in position by bolts or coach screws, or by other suitable means. These cells may be made of iron or wood, and may be removed for examination easily if necessary.

The feed is delivered into the hopper, over which is fixed a spray of water which forces the froth down the feed chute to the No. 1 upcast, containing water saturated with atomized air. When the froth leaves the feed chute, it is intercepted by an upcast containing minute air bubbles and water. There are five of these, or more if required, in series, which are generated by atomizing wheels driven by high-pressure water jets. These atomizing wheels are fixed in cells below the bottom of the machine, which may be made of iron or wood, and so confined that the water used in the driving of the atomizing wheels with the air is dashed upwards against circular iron mantles by the blades of the wheels. These spread the aerated water across the width of the bottom of the machine, where it intermingles with the pulp. The water dashing into the pulp has a washing effect, and the minute globules of air generated and forced up by the wheels have the effect of increasing the amount of air bubbles in the solution, which naturally join the small air bubbles already in the primary froth or feed to the machine.

The fact of these bubble films being enlarged makes the film more sensitive and more widely distributed in such a manner that the nature of the froth, reaching the overflow of the machine, is so changed that it will not hold the gangue in suspension; consequently the gangue passes through the machine as a tailing, and the cleaned sulphide particles are carried over the overflow lips of the machine as a cleaned product.

The air is led into the cells of the machine so as to impinge on the blades of the wheels. The amount of air required is very small, and is regulated according to requirements, and may be obtained from an ordinary air compressor, or if necessary, generated by a small blower placed at the head of the machine, driven by a small Pelton wheel. The necessary medium (if any) required for the ore under treatment might be inserted into the blower, where it will be forced into the machine and become atomized with the air, forced up and



THE MOUNT LYELL FLOTATION MACHINE.

distributed by the atomizing wheels, or fed in with the feed. These conditions would be necessary when the machine is on the primary flotation of sulphide ores, fine coal, or graphite.

The atomizing wheels are run without lubrication by oil or grease. The prevention of wear is effected by water under pressure injected through a hollow spindle on which the wheels revolve. A small hole less than $\frac{1}{16}$ in. in the spindle, about the centre of the boss of the wheels, allows the water to keep the wheel running on a water film, which protects the spindles from grit. This has been found more economical and satisfactory than lubrication by other means.

Extraction of Copper.—In the April issue we gave a brief notice of a method of extracting copper from oxidized ores by treating solutions with finely divided iron and recovering the precipitated copper by flotation. Our attention has since been drawn to the process owned by the Australian Minerals Recovery Co., of Perth, West Australia, and invented by P. W. Nevill and H. Soanes. The ore pulp, after fine crushing, is heated to 70° C. in agitators with finely divided metallic iron and a little free acid or a salt. The cement copper thus precipitated is separated from the gangue by elutriation or flotation. The process is a regenerative one, requiring only the addition of metallic iron with each cycle. It is claimed that the process consumes less than one-hundredth of the acid required by older hydrometallurgical methods; that there is relative economy in iron; that wear and tear on plant is light owing to the non-corrosive nature of the dilute solutions used; and that the reaction is much faster than with older methods, thus resulting in an increase in plant capacity. In a laboratory test on a small scale a 20 gram sample, heated by steam in a large test-tube with a little 0·5% sulphuric acid or a ferrous sulphate solution, in the presence of metallic iron, yielded its copper in three or four minutes, with rapid effervescence of carbon dioxide. On filtering the ferrous sulphate in the filtrate was found to bring about equally quick decomposition of a fresh batch of ore in the presence of added iron. Gold or silver, if present, is carried down with the copper. No metallic salt appears to interfere with the reaction, thus reducing the necessity of discarding foul solutions to a minimum.

Gillan's Gold Sluice-Box.—In the *Queensland Government Mining Journal* for February, E. C. Saint-Smith, Government Geologist, describes a new form of gold-saving machine for treating alluvial deposits, which he saw at work at Charters Towers. He reports that while no really new principle in mineral concentration appears to be involved in the machine, it proved very efficient during the test to which it was submitted, and, in addition, is very rigidly constructed and possesses little or no wearing parts to cause trouble during actual service. It may be described as an improved shaker. The timber framework is bolted together and can be readily taken to pieces to permit of its easy transport on pack horses. The full weight of the machine, including pump, water tank, machine, and supply pipe, totals 7 cwt. No nails have been used in the construction. The uprights are set on sole pieces to ensure rigidity when operating, and further stability is obtained by cross-bracing the framework. The mineral concentration is achieved on a galvanized iron tray, to the bottom of which are permanently attached semicircular cup-like riffles. These riffles have a maximum height above the floor of the tray of ⅞ in., tapering regularly to nil in a distance of 8½ in., the sides of the riffles being set at right angles to the plane of the tray. In the case of the machine seen by the writer, these riffles are 68 in number, and are arranged in parallel series grouped alternately. The tray is 4 ft. long by 2 ft. in width, and has a depth of 5 in. The sides and bottom of the tray are packed with rubber to minimize jarring effects. The tray is suspended by flat ⅛ in. steel bars, 2 ft. long by 1 in. wide. The sides of these steel carriers are also packed with rubber. The angle of slope to the tray is approximately 1 in. to the foot, but this pitch can be regulated as required by raising or lowering the framework. The tray is well stayed by metal cross-bars. A forward motion, at right angles to the tray, is imparted to the latter by means of the main drive, which is connected by either chain or belt to a counter-shaft, thence by a short eccentric to the tray, giving a total stroke of ¾ in. In the case of the machine seen by the writer, driving power (by hand) was applied to an ordinary bicycle-chain and sprocket wheel, but it could be easily belt-driven if desired. The position of the chain or driving wheels can be altered by utilizing a slot provided in the wooden framework to which they are attached. Instead of using hand power the machine could be operated by permitting the water and tailings to impinge on a small water-wheel set below the outfall end of the tray. The feed-box, which is arranged above the top end of the shaking tray, is 2 ft. in length and 18 in. maximum depth, the bottom sloping to the feed distributor below; the width reduces from 9 in. at the top to 5 in. at the bottom. At the bottom of the feed-box are two circular pipes, each 3 in. in diameter and about the same in height; these pipes deliver the feed on to the distributor; which latter consists of similar pipes, on top of which is sheet iron. As the body of the shaking tray is connected to these distributing plates, the material from the feed-box above is evenly received on to the tray, there being about ¼ in. clearance above the distributor plates, but a greater clearance can be secured when handling coarse material by lowering the plates. The water supply is regulated from a supply tank holding 200 gallons, set at an elevation sufficient to allow water therefrom to spray on to the material being treated in the machine. The end 2 ft. of this delivery pipe has thirty-seven perforations, evenly spaced in a double row, and so arranged that the back jets play directly on to the distributing plate in order to prevent clogging of the feed. To ensure rapid working and also to obtain the best concentration results, it is essential that the material to be treated should be dry and also graded as much as possible. Under these conditions the capacity of the machine is 40 lb. weight per minute, but it would be an easy matter to double this capacity by having a machine constructed with twice the width of shaking tray. The energy required to operate the machine seen by the writer is negligible.

Sillimanite as a Refractory. — The discovery of sillimanite in commercial quantities in India raises once more the question as to its value as a refractory. Sillimanite, as mineralogists are aware, is one of the crystalline forms of clay. Owing to its scarcity, many efforts have been made to form it artificially. Some particulars are given in a paper read recently by A. F. Greaves-Walker before the New York Section of the Society of Chemical Industry, and reproduced in the *Journal* of the Society for January 31.

A considerable amount of research work has been done during the past seventeen years in an effort to produce a refractory that would have a fusion point considerably above that of those made of the best grade of flint fireclay. The result of this work has been the recent development of at least one new refractory of this type, sillimanite, a stable silicate of alumina having the formula Al_2O_3,SiO_2. About twenty years ago a serious need began to be felt for a refractory that would not only withstand extremely high temperatures, but would carry heavy loads practically up to its fusion point, would resist the deteriorating effect of the blast from oil burners, and would withstand rapid and extreme fluctuations in temperature. It was about this time that the author began to work on the problem. At the time this work was being carried on very little was known about sillimanite, the main effort being directed towards obtaining from bauxite an aluminium oxide content as near 100% as possible. It was soon found in practice, however, that pure or nearly pure alumina had many unsatisfactory qualities, certain combinations of Al_2O_3 and SiO_2 being found superior from both a physical and a chemical standpoint. With the advent of the war several individuals and later the Bureau of Standards began intensive research work on refractories and porcelain for sparking plugs. This work led to the development of sillimanite and resulted in a wider knowledge of this silicate of alumina. Rankin and Wright constructed the melting point diagram for the binary system SiO_2—Al_2O_3, and Bleininger and others spent much time in determining the characteristics of sillimanite. They found that, being a stable compound, it remained rigid and could be used up to within a few degrees of its melting point; also that it had constant volume at high temperatures, had a low co-efficient of expansion that made its resistance to spalling high, and that it was neutral in its reaction. Furthermore, it was found that when sillimanite refractories were burned to a sufficiently high temperature they were impervious to slags and metals. It will be recognized that these characteristics are those of an ideal refractory. With the results of this and previous work and the knowledge gained through practical application of alumina refractories during previous years, it became possible to produce a material that had none of the faults heretofore encountered. It was necessary, however, to continue research work on raw materials from various localities and to solve the various problems of manufacturing, such as preparation of raw material, methods of forming ware, and methods of setting and burning. This work was undertaken by the American Refractories Company in conjunction with the Mellon Institute, and has progressed to a point where quantity production has already commenced.

SHORT NOTICES

Preserving Mine Timber.—The March *Journal* of the South African Institution of Engineers contains a paper by L. D. Hingle on the preservative treatment of mine timber.

Prestea Block A.—The February *Journal* of the Chemical, Metallurgical, and Mining Society of South Africa contains a paper by F. Wartenweiler on metallurgical treatment at Prestea Block A gold mine, West Africa.

Losses in Lead Smelting.—In the *Engineering and Mining Journal-Press* for April 8, C. Offerhaus describes the treatment of low-grade and undesirable lead ores, slags, etc., in Germany during the war.

Oxidized Copper Ores.—In the *Engineering and Mining Journal-Press* for April 15, P. F. Middleton describes his method of sulphatizing roasting of semi-oxidized ores having for its object to produce the maximum amount of water-soluble copper. We understand the author has a process on somewhat the same lines as the Webster process mentioned in the MAGAZINE for April and the Nevill-Soanes process described on p. 313 of this issue.

Radium.—In the *Journal* of the Society of *Chemical Industry* for March 31, A. G. Francis describes a method of recovering radium from decayed luminous paint.

Electrolytic Zinc.—In *Chemical and Metallurgical Engineering* for March 29, G. B. Scholl describes experiments on the effects of small proportions of arsenic, antimony, cobalt, nickel, etc., on the electrolytic precipitation of zinc from solutions.

Sulphuric Acid.—The *Journal* of the Society of Chemical Industry for April 15 contains a paper by J. W. Parkes describing the sulphuric acid plant of Kynoch, Ltd., Birmingham.

Effects of Pressure.—The *Journal* of the Franklin Institute for April contains an article by E. D. Williamson on experiments undertaken at the Geophysical Laboratory, Washington, in connexion with the change of physical properties of materials with pressure.

Gold Mining in Colombia.—In the *Engineering and Mining Journal* for March 25, E. K. Craig gives some account of gold mining in Colombia, mentioning the operations of the Pato and Nechi companies.

Potash in Texas.—In *Mining and Metallurgy* for April, David White, chief geologist of the United States Geological Survey, writes on the potash reserves in West Texas.

New South Wales Tin.—In the *Industrial Australian and Mining Standard*, J. W. Archibald reviews present conditions in the Tingha tinfield, New South Wales, pointing out that there are still extensive tracts of country suitable for dredging that would repay prospecting.

Minerals of Latin America.—In *Chemical and Metallurgical Engineering* for April 5, Otto Wilson commences a series of articles on the minerals, earths, and clays of Latin America.

South African Tin.—The *Transactions* of the Geological Society of South Africa for 1921 contains a paper by A. V. Krige on the geology of the Stellenbosch tin deposits near Cape Town.

African Geology.—In the *Geological Magazine* for April, F. P. Mennell writes on the northward and eastward extension of the Karroo lavas, dealing with Northern Rhodesia and Portuguese East Africa.

Asbestos.—In the *Engineering and Mining Journal-Press* for April 15, W. A. Rukeyser begins an article on asbestos mining and milling in Quebec.

Platinum Occurrence.—In the *Engineering and Mining Journal* for March 25, H. W. Turner gives examples of platinum occurring in quartz veins, these being exceptions to the often accepted theory that platinum is always found in association with ultra-basic rocks.

Galician Petroleum.—At the meeting of the Institution of Petroleum Technologists held on April 11, Albert Millar read a paper on Galicia and its petroleum industry.

Oil-Shales of Esthonia.—At the meeting of the Institution of Petroleum Technologists held on May 9, E. H. Cunningham Craig read a paper on the oil-shales of Esthonia. We hope to quote from this in our next issue.

RECENT PATENTS PUBLISHED

☞ *A copy of the specification of any of the patents mentioned in this column can be obtained by sending 1s. to the Patent Office Southampton Buildings, Chancery Lane, London, W.C. 2, with a note of the number and year of the patent.*

26,234 of 1920 (176,819). COBB ELECTRO REDUCTION CO., Toronto. An electric furnace for smelting complex ores, particularly complex tin ores.

28,539 of 1920 (152,289). H. J. E. HAMILTON, Broken Hill. In the treatment of Broken Hill slime, giving it a selective chloridizing roast at about 400° C. so as to form lead and silver chlorides without affecting the zinc sulphide, then leaching with brine solution and depositing the lead and zinc from the solutions on zinc, or other suitable metal.

35,796 of 1920 (176,549). OSMOSIS CO., LTD., J. S. HIGHFIELD, and D. NORTHALL-LAURIE, London. Improvements in the inventors' method of settling china and similar clay from water previous to drying.

36,255 of 1920 (176,918). A. COLLIER, Whitby. Plant and furnaces for manufacturing chemicals such as magnesium sulphate from blast-furnace slag.

36,519 of 1920 (176,924). G. SHIMADZU, Kyoto. Making lead oxides by igniting very finely powdered metallic lead, the heat of reaction being sufficient to keep up the oxidation when once started.

219 of 1921 (156,226). E. P. F. JALABERT, Constantine, Algeria. Improvements in ore concentrators in which sized minerals are classified in an upward current of water.

1,399 of 1921 (164,711). P. KESTNER, Paris. In the process of abstracting oxygen from water in a filter, in which the filtering medium consists of iron filings or turnings, regenerating the power of the iron to absorb oxygen by reducing the layer of rust formed on the surface of the filtering medium by allowing the rust and the iron to react upon each other at intervals, while the filtering action is suspended.

1,400 of 1921 (166,875). P. KESTNER, Paris. An improvement in the process of abstracting oxygen from water in metallic filters in accordance with the foregoing patent, consisting in causing the water to flow through the filter in opposite directions alternately, thereby affecting the regeneration of one portion of the filtering medium while the other is acting.

2,281 of 1921 (176,588). A. PEARSON, Burry Port. Removing the colour in crude oxide of zinc due to the presence of lead or cadmium oxide, by adding sufficient zinc sulphate to convert the coloured oxide into white sulphate.

9,931 of 1921 (177,067). W. MAUSS, Johannesburg. In vacuum filters methods of withdrawing and replacing the leaves.

14,231 of 1921 (176,713). LODGE FUME CO., and N. STALLARD, Birmingham. In electrostatic fume separators, an improved method of removing the precipitated fume.

25,258 of 1921 (177,117). METALLBANK UND METALLURGISCHE GESELLSCHAFT, Frankfurt-am-Main. In electrostatic fume separators, cooling the gas before entering the electrical field down to the dew point, and then reheating the gas in such a way as to prevent ionization through the action of flames.

NEW BOOKS, PAMPHLETS, Etc.

☞ Copies of the books, etc., mentioned below can be obtained through the Technical Bookshop of *The Mining Magazine*, 724, Salisbury House, London Wall, E.C. 2.

Use of Electrolytes in the Purification and Preparation of Clays. By H. G. SCHURECHT. Technical Paper 281 of the United States Bureau of Mines.

Sugar-Tube Method of Determining Rock Dust in Air. By A. C. FIELDNER, S. H. KATZ, and E. S. LONGFELLOW. Technical Paper 278 of the United States Bureau of Mines.

Oil Fuel at Sea; a Text-Book on Oil-Firing for Marine Engineer Officers. By "VISCO." Small octavo, cloth, 96 pages, illustrated. Price 5s. net. Newcastle-on-Tyne: Andrew Reid & Co., Ltd.

Text-Book of Mineralogy. Third Edition. By E. S. DANA and W. E. FORD. Cloth, octavo, 720 pages, illustrated. Price 25s. net. New York: John Wiley & Sons; London: Chapman and Hall, Ltd.

Text-Book of Fire Assaying. By E. E. BUGBEE. Cloth, octavo, 260 pages, illustrated. Price 15s. net. New York: John Wiley & Sons; London: Chapman & Hall, Ltd.

Mineral Land Surveying. Third Edition. By JAMES UNDERHILL. Cloth, octavo, 240 pages, illustrated. Price 17s. 6d. New York: John Wiley & Sons; London: Chapman & Hall, Ltd. This book describes the methods used in the survey of mineral lands in the western portion of the United States. In the new edition additions have been made to the section dealing with direct solar observation, and the field notes illustrating the requirements of the office of the United States Surveyor General for Colorado have been entirely re-written.

COMPANY REPORTS

East Pool and Agar. — This company was formed in 1913 to work the tin mines of this name between Camborne and Redruth, which had been in operation for many years previously under the cost-book system. At the same time Bewick, Moreing & Co. were appointed general managers. The event of recent years has been the discovery of the Rogers lode, which has supplied large quantities of high-grade ore. A year or more ago production was stopped owing to the fall in the price of tin, and shortly afterward the caving of ground, particularly round the main shaft, made it necessary to reconsider the policy of the company. After there had been much discussion and a public inquiry into the possibility of joint action between the company and its neighbours, particularly South Crofty, it was decided to proceed independently. The report for 1921 now issued gives an outline of the present position, and we quote this and the report by the general managers herewith at some length.

The directors report as follows:—On May 18, 1921, the old workings began to cave over an extensive area, and this movement lasted for several months, ultimately destroying both the hauling shafts, namely, East Pool shaft and Mitchell's shaft. It was decided, as soon as it was found that there was no hope of reopening the old shafts, to sink a new shaft, clear of all the old workings, in order to work the Rogers and other rich lodes already proved in the northern ground of Wheal Agar. The new shaft was commenced on January 12, 1922. Further capital is required to complete this shaft and equip it with the necessary machinery. For this purpose an issue of £75,000 of 10% participating preference shares is to be made, taking one-half of the profits of the company after payment of the preferential rate of 10%.

Bewick, Moreing & Co. report as follows: During the short period that full operations were carried out, namely, to the middle of February, 1921, development work was confined to the Rogers and other lodes. At the 190 fm. level, the main east drive on the Rogers lode was advanced 15 ft. in ore averaging 53 lb. black tin and wolfram per ton over a width of 5 ft., making the total length, so far opened up beyond the elvan, 263 ft., averaging 48·7 lb. per ton. The winze on this shoot of ore was sunk a further 37 ft. to a total depth of 61 ft., in values averaging 44 lb. per ton over a width of 5 ft., while the rise was extended 65 ft. to a total of 148 ft., disclosing ore averaging 155 lb. per ton. At the other extremity of the workings on the Rogers lode—namely, about 1,700 ft. farther west—the main drive, on the 212 fm. level, was advanced 19 ft. in ore, averaging 35·5 lb. black tin and wolfram per ton, over a width of 6·2 ft., while a rise from this drive was extended 11 ft. in similar values. In their previous report they stated that the main cross-cut at the 252 fm. level had intersected (at co-ordinate 537 ft. north) a lode which averaged 82 lb. black tin per ton over a width of 5 ft. Subsequently a west drive was advanced 12 ft. on this lode, disclosing ore averaging 141 lb., while an east drive was extended 13 ft. in values averaging 82·5 lb. per ton. What is considered to be the eastern continuation of one of the lodes met in the main cross-cut, possibly the above-mentioned lode, was intersected by a diamond-drill bore-hole from the Tolgus tunnel, where it averaged 38 lb. black tin per ton over a width of 3 ft. These two points are separated by a distance of no less than 2,500 ft., and the present indications are that in this section of the property, which is highly mineralized, large quantities of profitable ore will be developed. Of the 10,074 tons of ore treated, which averaged 35·5 lb. black tin per ton, about 85% was won from the Rogers lode. This proportion was being rapidly increased prior to the suspension of operations, owing to the scarcity of ore in the old part of the mine, which now contains only isolated and low-grade remnants.

On May 18 an extensive fall of ground occurred, starting in one of the large stopes on the Great Lode—in a section where it was worked many years ago—and extending upward for about 300 ft. to the East Pool shaft. This resulted in the collapse of the shaft at about the 130 fm. level, where the ground caved for a width of about 70 ft. The shaft had been previously strengthened by means of reinforced concrete pillars to protect it against a possible movement, but these precautions were of no avail in such an extensive subsidence as that which occurred. Every effort was made to repair the shaft and restart the electrically-driven pumps which had been stopped at the outset by the subsidence, and it was hoped that this might be accomplished, but subsequent large falls of ground, which continued intermittently for a long period, eventually made this work impossible. It was then decided to recover, from the old section of the mine, the accessible material and equipment, and to take steps to isolate it from the rich northern and eastern ground containing the Rogers and other lodes. To reduce the pumping charges dams had already been placed in some of the lower cross-cuts to raise the water from the Rogers lode to a higher pump station. These dams were strengthened where necessary, and others constructed, upon the decision being reached to permanently cut off the old workings.

For the future working of the property it was also decided to sink a new shaft, and after a careful investigation this work was commenced on January 12, 1922, at a site about 720 ft. north of the Agar shaft. All of the rich lodes discovered in the property during recent years will become accessible through this new shaft, and they comprise: (1) The Rogers lode, which has been opened up with such gratifying results for a continuous length of about 1,700 ft., and still shows high-grade ore in the most easterly and westerly workings. This lode traverses the full length of the property, namely, about 4,600 ft., and on the east enters the Tolgus mines. There is already developed on the Rogers lode a large tonnage of ore, which will become available for extraction immediately the new shaft and the connexions to the existing workings on this lode are completed. (2) Two lodes found in driving the main cross-cut at the 252 fm. level, assaying respectively 37 and 108 lb. black tin per ton. The eastern extension of one of these lodes was, as already mentioned, intersected by a diamond-drill bore-hole from the Tolgus tunnel, a distance of about 2,500 ft. away, where it assayed 38 lb. per ton. (3) A lode, found by diamond-drilling, lying north of the Rogers lode, carrying values averaging 37 lb. per ton. (4) The eastern continuation of the Great lode, met in the driving of the Tolgus tunnel, where it averaged 158 lb. black tin and wolfram per ton. All these lodes lie in the northern and eastern portion of the property. Although development work has already proved this to be a highly mineralized zone, containing several lodes of very good value, it cannot yet be said to have been even fully prospected, and the discovery of additional lodes might be reasonably anticipated.

The new shaft will be more centrally situated for the working of the valuable parts of the property than was the old East Pool shaft, and will enable the underground work to be conducted throughout by more economical methods than was possible when operating under past conditions. These improved circumstances, together with lower prices for mining stores and supplies, should result in the reduction of working costs to a level closely corresponding to that of the pre-war period, when they averaged about 19s. per ton, and should enable the ore already proved by development work to be profitably extracted, even at the present low price of tin.

Nipissing Mines. — This company has worked an extensive silver property at Cobalt, Ontario, since 1904, and not only has the output been large, but the mine has been famous for the many innovations introduced in the metallurgical treatment of silver. The report for 1921 shows that throughout the year all the ore has been sent direct to stamps, instead of the rich ore being picked out and treated separately. The ore treated totalled 80,720 tons, averaging 41·58 oz. silver per ton. In the "low-grade mill" below the stamps silver bullion was recovered by cyaniding, together with 1,321 tons of coarse concentrate averaging 1,580 oz. silver per ton, and 177 tons of fine concentrate averaging 511 oz. per ton. At the "high-grade mill" 1,511 tons of concentrate averaging 1,498 oz. per ton was treated, together with 73 tons of custom ore averaging 1,812 oz. and 41 tons of by-products averaging 2,301 oz. The silver bullion extracted by cyaniding in both mills was sent to the refinery. The amount of fine silver shipped during the year was 3,155,539 oz. With regard to metallurgical practice at the high-grade mill, bleaching powder is no longer added in the tube-mill, but the ground ore is now agitated in a 3% sulphuric acid solution in order to eliminate cyanicides, particularly the oxidized compounds of nickel. After two washes the remaining acid is neutralized with lime, and the usual cyanide treatment follows. This preliminary acid treatment effects a saving of 25 to 30 lb. of cyanide per ton of ore treated. The residues discharged from the high-grade mill averaged 57 oz. silver per ton and 6·8% cobalt; owing to the dullness in the cobalt market, none of this residue was shipped. During the year 2 tons of nickel ore was shipped. The accounts show the gross value of the output at $1,869,566 and the working cost $900,779. The dividends absorbed $935,000. Development has been actively continued, but the ore disclosed did not contain as much silver as that milled during the year. The reserve at December 31 was estimated to contain 3,004,939 oz., or 564,000 oz. less than the year before. The report mentions that properties are being investigated at The Pas district in Manitoba, but no hint of their prospective value is given.

Waihi Gold.—This company was formed to work gold deposits in the north island of New Zealand in 1887. Regular production began in 1892, and the first dividend was paid for the year 1893. For many years handsome profits were made, but from 1910 onward the output has been on a diminished scale owing to the assay-values decreasing with depth. The report for 1921 shows that 164,042 tons of ore was treated, averaging 6·3 dwt. gold and 2·6 oz. silver per ton. The yield of gold-silver bullion was 459,654 oz., selling for £307,972, and £40,322 was realized from a special clean-up at the refinery. The sale of electric power to the New Zealand Government brought an income of £10,625, and £26,344 was received as interest on investments. The working cost was £278,670, taxes absorbed £46,140, £14,138 was written off for depreciation, and £49,590 was distributed as dividend, being 2s. per 10s. share. Development has been on a greater scale than was possible during several recent years, but the reserve has not been maintained, standing now at 681,860 oz., averaging 34s. 2d. per ton, taking gold at par and silver at 2s. per oz., as compared with 778,565 tons, averaging 33s. 9d. the year before. The most encouraging feature is that the Martha lode is wider and more promising on the twelfth than on the eleventh level. The company's articles of association are being amended so that mining work of any kind can be undertaken in any part of the world, and several propositions have already been before the board. The company has a reserve fund of over £360,000.

Nundydroog Mines.—This company belongs to the John Taylor & Sons group, and has worked a gold mine in the Kolar district, Mysore State, South India, since 1880. Production commenced in 1882, and dividends have been paid since 1888. Eighteen months ago additional capital was subscribed for the purpose of pressing development at depth. The report for 1921 shows that 105,682 tons of ore was raised, from which 55,755 oz. of gold was extracted by amalgamation, and that 53,520 tons of sandy tailing and 108,970 tons of slime were treated by cyanide for an extraction of 7,267 oz. of gold. The total gold output was 63,022 oz., which was valued at £333,829, and the working cost was £213,533. The shareholders received £56,452, the dividend being at the rate of 20%. The ore reserve is estimated at 175,200 tons, as compared with 165,800 tons the year before. More success attended the development than was the case in 1920, but the lean period continues, and unless some better ore is discovered soon the average grade sent to the mill will be reduced still further.

Ooregum Gold.—This company belongs to John Taylor & Sons' group operating gold mines in the Kolar district, Mysore State, South India. It was formed in 1880, and was reconstructed in 1885. Production started in 1888, and dividends have been paid continuously since 1890. The report for 1921 shows that 154,000 tons of ore was raised and sent to the stamps. The amount of gold extracted by amalgamation was 89,618 oz., and by cyanide 11,215 oz., making a total of 100,833 oz. In addition 759 oz. was extracted by the cyaniding of accumulated slime. It is noteworthy that this output of gold is the largest on record, and compares with 74,624 oz. extracted from 158,766 tons in 1903, the year when the present scale of tonnage operations was inaugurated. The gold realized £537,621, of which about £105,000 accrued from premium. The working cost was £270,048, and after the payment of royalty, etc., the working profit was £246,397. Out of this profit £21,000 is written off for depreciation and £37,036 for expenditure on the new circular shaft, while £60,000 is transferred to mine equipment account. The shareholders received £93,173, being at the rate of 32½% on the preference shares and 22½% on the ordinary shares. The developments during the year were highly satisfactory, and the reserve is estimated at 419,245 tons, as compared with 414,824 tons the year before. The new ore-shoot found at the 64th level in Taylor's section constitutes the most important discovery made for some time past. In Oakley's section the valuable ore-shoot has been proved on the 64th, 65th, and 66th levels. The mine is now so deep that further provision for ventilation and cooling is to be made.

Champion Reef Gold Mines of India.—This company belongs to the John Taylor & Sons group operating gold mines in the Kolar district, Mysore State, India. From 1894 to 1905 dividends were paid on a handsome scale, and from then onward the dividends were lower. It was reconstructed as from October 1, 1921, for the purpose of raising further funds for development in depth. The present report covers three months from October 1 to December 31, 1921. During this period 34,493 tons of ore was sent to the stamps. The yield of gold by amalgamation was 11,901 oz., and by cyanide 2,809 oz., making a total of 14,710 oz. Of this total 888 oz. came from the treatment of 14,946 tons of old tailing. The sale of the gold brought £73,095, and the profit was £7,059. The ore reserve at December 31 was 221,946 tons, as compared with 248,846 tons on September 30, 1920. At present attention is devoted largely to the improvement in the means for ventilation at depth. When this work is completed, the development of a new shoot of ore at the bottom of Carmichael's section will be undertaken ; also exploration to the north of Carmichael's shaft from the 53rd level downward, at the 57th and 61st levels toward the south boundary, and lateral exploration of the East lode at several points in various levels.

Mason and Barry.—This company has worked the San Domingos cupriferous pyrites mines at Mertola, Portugal, since 1853. The report for 1921 shows that the company has recovered from the adverse effects of the war in a most gratifying manner. The amount of ore raised during the year was 148,261 tons, as against 93,812 tons in 1920, and the shipments, including washed ore, were 204,400 tons, as against 226,739 tons. The yield of copper was 433 tons. The profit was £115,772, which includes £18,000 income tax refunded. A dividend of 40% less income tax, and a bonus of 10%, tax free, have been declared, absorbing £92,586.

Tharsis Sulphur and Copper.—This company has worked pyrites mines in the south of Spain since 1866. The headquarters are in Glasgow, and it has several works in this country where burnt pyrites is treated for the recovery of copper, with purple oxide of iron as a valuable by-product. The report for 1921 shows that at the Tharsis mine 38,181 tons of ore was extracted, as compared with 62,298 tons the year before, and that at the Calanas mine 222,577 tons was extracted as compared with 251,620 tons. The decrease is due solely to the poor demand for pyrites owing to the world's depression of trade. The metal works have been idle most of the year, but operations are being gradually resumed as an outlet offers for the purple ore. The trading profit was £129,525, and after payment of taxes and cost of administration, and allowing for depreciation, the net profit was £45,944. Owing to the uncertain position of trade it is considered best not to distribute any dividend, the first occasion on which such an event has happened in the history of the company.

Apex (Trinidad) Oilfields.—This company was formed in 1919 to acquire oil rights in the Fyzabad district, Trinidad. The Anglo-French Exploration Co. and the British-Borneo Petroleum Syndicate are largely interested. The report for the year ended September 30, 1921, shows that operations were retarded by the fire at No. 3 well in November, 1920, and the subsequent necessary reorganization of work and restoration of plant. The production of crude oil was 44,494 tons, of which 43,453 tons was produced during the seven months May to September. The deliveries of oil to Trinidad Leaseholds, Ltd., for refining and marketing were 37,402 tons. The profit was £72,970, from which had to be deducted £15,984 for depreciation of wells and £18,859 for the damage done by the fire. The original arrangement for the sale of the oil production to Trinidad Leaseholds, Ltd., provided for deliveries to be taken up to 2,000 tons per month to July 31, 1921, and thereafter up to 5,000 tons per month. Subsequent arrangements have been made, subject to the adjustment of details, for increasing the deliveries to be taken up to 10,000 tons per month, as soon as the purchasers are in a position to deal with this increased tonnage. In the meantime, production is being restricted to meet the present limited delivery requirements, and the subject of the disposal of any surplus production which may not be taken by Trinidad Leaseholds, Ltd., is under investigation. Drilling operations have been directed towards both production and test purposes, and have been attended with most successful results both in the way of obtaining production and in demonstrating the value of the property, and although the bringing in and operation of the wells has been hampered by the restriction of deliveries, 12 wells have been sunk to date, of which 10 have been brought in or are ready to be brought into production as soon as increased deliveries can be taken. The bringing in of No. 7 well with a heavy flow in August last necessitated closing down the other wells, and since then the greater part of the deliveries have been met by a regulated flow from that well, the balance having been provided from limited test operations and from a new flowing well, No. 8, recently brought in. Development work has mainly been on sands located at about 1,050 ft. to 1,400 ft. in depth, varying with the position of the well sites. Good results have also been obtained from shallow sands much nearer the surface. Tests will be made of the deeper oil-bearing zones at a later stage.

Randfontein Central.—This company operates gold-mining properties in the far west Rand, being formed in 1907 to consolidate a number of properties previously worked independently. Sir J. B. Robinson was controller in those days, but he sold out to the Barnato group a few years ago. Since then the underground operations have been entirely remodelled and new shafts sunk, according to a plan described in our issue of January, 1921. The report for 1921 shows that 1,461,000 tons of ore, averaging 6·14 dwt., was raised and sent to the mill. The yield of gold by amalgamation was 268,484 oz., and by cyanide 159,408 oz., making a total of 427,892 oz., being at the rate of 5·85 dwt. per ton. The revenue from the sale of gold was £2,270,766, or 31s. 1d. per ton, the gold selling at 106s. 2d. per oz. The working cost was £2,025,448, or 27s. 9d. per ton, leaving a working profit of £245,318, or 3s. 4d. per ton. Debenture interest absorbed £131,244, and interest on money advanced by Randfontein Estates £40,273, while £77,529 was appropriated toward capital expenditure and debenture redemption. The reorganization of mining methods is now practically complete, and nothing is required for bringing operations to full capacity but an adequate supply of native labour. Unfortunately the steepness of the reefs and the amount of climbing to be done make the mine less popular with the natives than the flatter mines at the other end of the Rand. The ore reserve is estimated at 4,142,100 tons averaging 6·2 dwt., as compared with 3,593,410 tons of the same tenor a year ago.

New Unified Main Reef.—This company was formed in 1893 by the Barnato group to consolidate gold-mining properties in the middle west Rand. Milling started in 1893, but was suspended from 1894 to 1898, and also, of course, during the Boer war. Dividends have been paid regularly since 1908, but both operations and dividends have been on a small scale. The report for 1921 shows that 133,700 tons of ore, averaging 4·75 dwt. per ton, was mined and sent to the mill. The yield of gold by amalgamation was 18,277 oz., and by cyanide 11,825 oz., making a total of 30,102 oz. The revenue including premium was £159,086, and the working cost £134,879, leaving a working profit of £24,207. The shareholders received £25,000, the rate being 10%. The ore reserve is estimated at 38,900 tons, averaging 6·2 dwt., as compared with 83,000 tons of the same tenor a year ago. There is little stoping ground left, but some low-grade Main Reef and reclamation ore remains to be treated. The period for which the mine can still be operated depends on the premium and any possible reduction in costs.

Langlaagte Estate and Gold.—This company was formed in 1888 to work gold claims in the western part of the central Rand. Control at first was with J. B. Robinson, but subsequently passed to the Barnato group. The report for 1921 shows that 480,760 tons of ore averaging 6·45 dwt. per ton was raised and sent to the mill. The yield of gold by amalgamation was 94,654 oz., and by cyanide 52,542 oz., making a total of 147,197 oz. The revenue from the sale of gold was £779,036, and the working cost was £629,280, leaving a working profit of £149,756. The shareholders received £110,812, the dividend being at the rate of 12½%. The reserve is estimated at 950,000 tons averaging 6·4 dwt. per ton, as compared with 1,016,800 tons of the same tenor the year before. The fall is due to the ground near the main shaft being much disturbed by dykes and the ore developed being of low grade.

Consolidated Langlaagte.—This company belongs to the Barnato group and was formed in 1902 to work deep-level property in the western part of the central Rand. The report for 1921 shows that 484,600 tons of ore averaging 6·22 dwt. gold per ton was sent to the stamps. The yield of gold by amalgamation was 104,460 oz., and by cyanide 40,169 oz., making a total of 144,629 oz. The sale of gold realized £765,840, and the working cost was £593,544, leaving a working profit of £172,608. The shareholders received £118,750, the rate being 12½%. The development results have been rather better than they were during the preceding year or two, and the assay-values have proved higher than was anticipated. The reserve stands at 1,371,000 tons averaging 6·5 dwt., as compared with 1,339,000 tons averaging 6·2 dwt. the year before, and 2,090,300 tons averaging 6·2 dwt. at the end of 1919. The current developments, however, continue to be of somewhat uncertain nature.

Crown Mines.—This company belongs to the Central Mining-Rand Mines group, and was formed originally as the Crown Deep in 1892 to work deep-level property below the Crown Reef mine in the central Rand. In 1909 a large amount of adjoining property laterally and on the dip was absorbed, and underground operations were remodelled so that the property could be worked on a large scale. The report for 1921 shows that 2,399,831 tons of ore was raised, and that, after the removal of 9% waste, 2,177,800 tons, averaging 6·1 dwt. gold per ton, was sent to the stamps. The yield of gold by amalgamation was 470,099 oz. and by cyanide 172,906 oz., making a total of 643,005 oz. The par value of this gold was £2,700,625 or 24s. 9d. per ton, and the revenue including premium was £3,388,748 or 31s. 1d. per ton. The working cost was £2,716,717, or 25s. per ton, leaving a working profit of £672,030, or 6s. 2d. per ton. It will be seen from the above figures that but for the premium the balance would have been slightly on the wrong side. The shareholders received £305,534, the dividend being at the rate of 32½%. Out of the profit £213,815 was allocated to capital expenditure. During the year 79% of the ore developed was payable, and the amount added to the reserve was 2,250,400 tons, averaging 6·3 dwt. per ton. The total reserve is estimated at 8,511,200 tons, averaging 6·1 dwt. per ton.

City Deep.—This company belongs to the Central Mining-Rand Mines group and was formed in 1899 to work deep-level property in the central Rand, on the dip of the City and Suburban, Meyer and Charlton, Wolhuter, and Goch. Plans are now in hand for the development of the southern sections by means of a new vertical shaft, which is now in course of sinking to 7,000 ft. The report for 1921 shows that for the first time it has been possible to keep the mill working to capacity, the reason being that the labour supply has come up to requirements. The amount of ore raised was 1,130,917 tons, and after the removal of 12% waste, 995,100 tons averaging 8·69 dwt. gold per ton was sent to the stamps. The yield of gold by amalgamation was 295,258 oz., and by cyanide 123,183 oz., making a total of 418,441 oz. The revenue from the sale of the gold was £2,198,825, of which £441,376 accrued from premium. The working cost was £1,487,309, leaving a working profit at par of £270,140, or a total of £711,516. The shareholders received £485,625, the dividend being at the rate of 37½%. The ore reserve at December 31 was estimated at 2,428,300 tons averaging 8·8 dwt. per ton, as compared with 3,099,200 tons averaging 9 dwt. the year before, and 3,418,425 tons, averaging 9·4 dwt. at the end of 1919. The reason for the fall during 1920 was the poor results of development, but in 1921 the fall is attributed to so much of the development being dead work on main haulages, cross-cuts, etc.

Village Deep.—This company belongs to the Central Mining-Rand Mines group, and works a deep-level property in the central Rand to the west of City Deep. The report for 1921 shows that 649,094 tons of ore was raised and that after the rejection of waste 581,800 tons averaging 6·59 dwt. gold per ton was sent to the stamps. The extraction of gold by amalgamation was 115,667 oz., and by cyaniding 68,550 oz., making a total of 184,217 oz. The par value of the gold was £773,630, and the premium received amounted to £951,634, altogether £969,264. The working cost was £856,518, leaving a working profit of £112,745. The revenue per ton at par was 26s. 7d., and with premium 33s. 4d., while the cost per ton was 29s. 5d. The ore reserve is estimated at 1,544,900 tons, averaging 6·4 dwt. as against 1,872,300 tons averaging 6·2 dwt. the year before.

Geldenhuis Deep.—This company belongs to the Central Mining-Rand Mines group, and has worked a deep-level property in the eastern part of the central Rand since 1893. For many years excellent dividends were paid, but the mine is now near exhaustion. The report for 1921 shows that 610,679 tons of ore was raised, and that after the removal of waste, 573,150 tons, averaging 5·62 dwt. per ton, was sent to the stamps. The yield of gold by amalgamation was 98,439 oz. and by cyanide 55,011 oz., making a total of 153,450 oz. The normal value of this gold was £644,302, corresponding to 22s. 5d. per ton, and £161,666 was received as premium, bringing the revenue to £805,968 and the yield per ton to 28s. 1d. The working cost was £803,452, or 28s. per ton. It will be seen that though a large increased revenue was obtained due to the high price of gold, expenses were only just met. Development during the year has failed to maintain the reserve, which now stands at 914,200 tons, averaging 6·7 dwt. per ton, as compared with 1,467,100 tons, averaging 6·1 dwt. the year before. The fall is partly due to there being only a small amount of ground left for development and partly to the elimination of blocks of a lower grade than can be worked under present conditions. If costs came down substantially, blocks totalling 778,000 tons might be included in the reserve. It will be seen that with the fall in gold premium it is doubtful whether operations can be continued for long; and it would require a considerable reduction in costs to make it possible to operate at the present level of the premium. But in any case the available ore is very restricted.

Rose Deep.—This company, which belongs to the Central Mining-Rand Mines group, was formed in 1894 to acquire gold-mining claims on the dip below Primrose in the near east Rand. In 1909 the adjoining Glen Deep was absorbed. The report for 1921 shows that 706,957 tons was raised, and that after the removal of 9% waste, 643,450 tons, averaging 5·23 dwt. gold per ton was sent to the stamps. The yield of gold by amalgamation was 98,473 oz., and by cyanide 59,697 oz., making a total of 158,170 oz. The revenue derived from the sale of gold was £833,024, of which £168,838 accrued from premium. The working cost was £708,177, leaving a working profit of £124,906. This is the first time that this mine has had to depend on the premium for a profit, in spite of the fact that the ore is of low grade. The yield per ton at par was 20s. 7d., the cost per ton 22s., and the revenue from premium per ton 5s. 3d. The shareholders received £105,000, the dividend being at the rate of 15%. The ore reserve is calculated at 2,564,430 tons, averaging 5·2 dwt. per ton, as compared with 3,060,040 tons, averaging 5·1 dwt., the year before. The fall in tonnage is largely due to the necessity for eliminating from the estimate considerable amounts of ore below a certain limit of grade. In order to effect economies the Glen Deep mill is to be put out of use, and the Rose Deep mill extended to handle 53,000 tons per month. Owing to the mine's neighbour on the east, Knight's Deep, closing down, it has become necessary to rearrange pumping facilities. An agreement has accordingly been made with Simmer & Jack on the west to install a joint pumping plant.

New Primrose Gold.—This company belongs to the Barnato group, and was formed in 1887 to acquire claims on the outcrop in the middle east Rand. Excellent dividends were paid for many years, but four years or so ago the development was completed, and operations have since been on a smaller scale. At about the same time the remaining portions of the adjoining May and Glencairn properties were acquired. The report for 1921 shows that 256,700 tons of ore, averaging 4·66 dwt. per ton, was raised and sent to the stamps. The yield of gold by amalgamation was 39,561 oz., and by cyanide 15,959 oz., making a total of 55,520 oz. The revenue including premium was £293,802, and the working cost was £255,208, leaving a working profit of £38,594. The shareholders received £40,625, the rate being 12½% The ore reserve is estimated at 25,100 tons, averaging 8·3 dwt. per ton, and much reclamation remains to be done over a wide range of workings, so that with favourable conditions operations may be continued for a year to two. Everything depends, however, on the gold premium and the level of costs.

Witwatersrand Gold.—This company belongs to the Barnato group and has worked a mine in the middle east Rand since 1887. The report for 1921 shows that 500,344 tons of ore was raised, and that after the removal of 10% waste, 448,300 tons averaging 5·5 dwt. gold per ton was sent to the stamps. The yield of gold by amalgamation was 87,929 oz., and by cyanide 29,805 oz., making a total of 117,734 oz. The revenue from the sale of the gold was £623,076, and the working cost was £532,022, leaving a working profit of £91,054. The shareholders received £117,406, the rate being 25%. The ore reserve is calculated at 547,300 tons averaging 5·8 dwt. per ton, as compared with 774,500 tons averaging 6 dwt. the year before, and 1,142,500 tons averaging 5·9 dwt. at the end of 1919. Very little payable ore has been developed lately, and there are no rich patches among the reserves. The prospect of working at a profit depends largely on a reduction of working costs, now that the premium is gradually becoming less.

Knight Central.—This company was formed in 1895 to work a second deep in the middle east Rand. The company was worked by the Neumann group for many years, and was subsequently transferred to the Central Mining-Rand Mines control. Little profit has ever been made, and the question of closing has often arisen. This is the position at present, and liquidation may be expected before long. The report for 1921 shows that 327,300 tons of ore averaging 5·23 dwt. gold per ton was mined and sent to the mill. The yield of gold by amalgamation was 46,187 oz., and by cyanide 33,284 oz., making a total of 79,471 oz. The revenue from the sale of gold was £417,225, of which £83,659 accrued from premium. The working cost was £386,589, leaving a working profit of £30,636. If it had not been for the premium there would have been a loss of £53,023. The yield per ton at par was 20s. 5d., and the working cost was 23s. 8d. The working loss per ton at par was 3s. 3d., and the actual working profit per ton was 1s. 11d. No dividend was distributed. Recent development has given poor results, and though there is still a large untouched area little inducement exists for the continuance of exploration. The block of ore east of the East Shaft, which has been the mainstay of the company since 1917, is practically exhausted, and of the remainder of the reserve, 147,800 tons averaging 5·6 dwt. per ton, only a small porportion will be recoverable.

Witwatersrand Deep. — This company was formed in 1895 to acquire deep-level property in the middle east Rand. Control was with the Central Mining-Rand Mines group for many years, but three years ago local shareholders acquired control. Judging by the letters in the Press and the circulars issued there is still a lack of unanimity on the board and among shareholders. The report for 1921 shows that 418,139 tons was raised from the mine, and that after the removal of 2½% waste, 406,830 tons, averaging 6·04 dwt. gold per ton was sent to the stamps. The yield of gold by amalgamation was 83,782 oz., and by cyanide 33,045 oz., making a total of 116,827 oz. The revenue from the sale of gold was £610,981, of which £133,077 represented premium. The revenue per ton at par was 23s. 6d., and from premium 6s. 6d. The working cost was £526,092, or 25s. 10d. per ton, leaving a total working profit of £84,888, or 4s. 2d. per ton. It will be seen that, without premium, there would have been a loss on the year's operations. The ore reserve is estimated at 1,067,440 tons averaging 6·6 dwt. per ton, as compared with 1,018,390 tons averaging 6·3 dwt. the year before. Developments at depth on the East Shaft south incline have given good results, and the general outlook is reported to be fairly encouraging.

East Rand Proprietary Mines.—This company was formed in 1893 by the Farrar group to work property in the East Rand, just to the west of the Boksburg break. For some time the company was successful financially, and operations were always on a very large scale, but of recent years the ore has been of low grade and the question of closing-down has often been imminent. During the last few years the mine has been managed by the Central Mining group. The report for 1921 shows that 1,506,000 tons, averaging 5·5 dwt. gold per ton was sent to the mill, where 227,225 oz. was extracted by amalgamation and 169,060 oz. by cyaniding, being a total of 396,285 oz. The revenue from the sale of the gold was £2,084,717, of which £420,497 represented premium. The working cost was £2,006,459, and the working profit £78,257. If it had not been for the premium there would have been a working loss of £342,239. The revenue per ton at par was 22s. 1d., the working cost per ton 26s. 8d., and the revenue from premium per ton 5s. 7d. Development has been continued in several sections where things looked most promising, and fairly satisfactory results were obtained, though the amount of ore developed was less than it should be. Moreover, it was necessary to omit many blocks from the reserves on account of high costs and falling premium. The reserve tonnage thus showed a decrease during the year, standing on December 31 at 1,946,654 tons, averaging 6·7 dwt., as compared with 2,410,850 tons, averaging 6·1 dwt. the year before. The future of the mine continues obscure.

New Kleinfontein. — This company belongs to the Anglo-French Exploration Co., and was formed in 1890 to acquire gold-mining property in the Far East Rand. In 1910 the adjoining Benoni and Apex properties were absorbed. The Apex mill is now leased to Modderfontein East, and the property is not being worked. The report for 1921 shows that 682,083 tons of ore was raised, and that after the removal of 14% waste, 581,060 tons averaging 5·78 dwt. per ton was sent to the stamps. The yield of gold by amalgamation was 103,379 oz., and by cyanide 55,629 oz., making a total of 159,009 oz. The revenue from the sale of this gold was £833,803, the gold being sold at an average price of 104s. 10d. The working cost was £768,778, leaving a working profit of £65,025, out of which £57,577 was paid as dividend, being at the rate of 5%. The ore reserve is calculated at 1,325,333 tons averaging 5·18 dwt. per ton, as compared with 1,623,574 tons averaging 5·32 dwt. the year before, and 1,923,474 tons averaging 5·61 dwt. at the end of 1919.

Government Gold Mining Areas (Modderfontein).—This company belongs to the Barnato group, and was formed in 1910 to work a large property in the Far East Rand. It was the first gold-mining company to be organized by direct dealing with the Government, with a portion of the profits going to the latter. It shares with New Modderfontein the honour of being at the top of the list of Rand producers. The report for 1921 shows that 1,908,344 tons of ore was raised, and that after the removal of 15% waste, 1,625,500 tons averaging 8·57 dwt. gold per ton was sent to the stamps. The extraction of gold by amalgamation was 370,403 oz., and by cyanide 295,416 oz., making a total of 665,819 oz. The par value of this gold was £2,828,220, and the working cost £1,757,911, leaving a working profit at par of £1,070,309. In addition £962,181 was received in respect of premium, so that the total working profit was £1,762,490. The Government's share of this profit was £896,181, and £770,000 was distributed among shareholders, being at the rate of 55%. The sum of £413,002 was appropriated to capital expenditure, of which about £125,000 is to be spent on a new central shaft for ventilating purposes. The revenue at par per ton was 24s. 9d., and the cost per ton 21s. 7d. The ore reserves at December 31 last were estimated at 10,232,000 tons averaging 8·5 dwt. per ton, as compared with 10,291,000 tons averaging 8·2 dwt. the year before. The development work done during the year consisted not so much of the opening of new areas as of blocking out the large areas already exposed. The ground to the south of the southern dyke is being developed with satisfactory results. In the north-east section of the property three drives are being advanced toward the Geduld boundary on the 10th, 12th, and 14th levels; the 14th level revealed satisfactory values, but the results on the 10th and 12th levels were irregular. All the development in the west part of the mine has given good results.

Van Ryn Deep.—This company belongs to the Barnato group and was formed in 1902 to work a gold-mining property in the Far East Rand between Kleinfontein and New Modderfontein. The report for 1921 shows that 815,533 tons of ore was raised, and that after the removal of 25% waste, 611,400 tons averaging 10·97 dwt. gold per ton was sent to the stamps. The extraction by amalgamation was 226,285 oz., and by cyanide 100,721 oz., making a total of 327,006 oz. The value of this gold at par was £1,381,294, and the costs were £810,777, leaving a working profit at par of £570,517. An additional income of £352,401 accrued from the premium on gold, making the total working profit £922,918. The shareholders received £718,135, the dividend being at the rate of 60%. The ore reserves are calculated at 3,317,000 tons averaging 9·2 dwt. per ton, as compared with 3,260,000 tons averaging 9·7 dwt. The fall in assay-value is due to the ore developed in the western section of the mine having been of lower grade. The south-east corner of the property is now being developed, and ore of high grade has already been disclosed on the eastern boundary.

Modderfontein Deep Levels. — This company belongs to the Union Corporation (formerly Goerz) group, and has been one of the producers of gold in the Far East Rand since 1914. The report for 1921 shows that 647,213 tons was mined, and that after sorting below and above ground 509,250 tons, averaging 11·3 dwt. per ton was sent to the mill. The yield of gold by amalgamation was 176,223 oz., and by cyaniding 104.132 oz., making a total of 280,355 oz. The revenue from the sale of gold was £1,477,610, of which £287,290 accrued from premium. The working cost was £522,588, and the cost of development £38,197, leaving a working profit of £916,824. The shareholders received £750,000, the dividend being at the rate of 150%. During the year development has continued to give highly satisfactory results. The reserve at December 31 was estimated at 4,375,000 tons, averaging 9·3 dwt., as compared with 4,100,000 tons, averaging 9·4 dwt. the year before.

Geduld Proprietary Mines. — This company belongs to the Union Corporation (formerly Goerz) group, and was formed in 1899 to work a gold mine on the Far East Rand. The report for 1921 shows that 646,413 tons was mined, and after the removal of 9% waste underground and 8% on the surface, 537,800 tons averaging 7·62 dwt. was sent to the stamps. The yield of gold by amalgamation was 85,563 oz., and by cyanide 104,423 oz., making a total of 189,986 oz. The revenue including premium was £1,004,023, and the working cost £634,457, leaving a working profit of £369,565. The shareholders received £220,916, the rate being 17½%. A favourable feature of the year's work was that the cost per ton was 23s. 7d., as compared with 24s. 1d. the year before. The development continues to give good results, particularly in the southern area in the vicinity of No. 7 shaft. The reserve is estimated at 3,545,000 tons, averaging 8·1 dwt. per ton, as compared with 3,220,000 tons, averaging 8 dwt., the year before, and 2,580,000 tons, averaging 7·4 dwt. at the end of 1919.

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EDITORIAL

WE record the passing of a sentence of seven years' penal servitude on Mr. Horatio Bottomley, once well known in the mining market, but defer comment owing to an appeal having been lodged.

WITH regard to the conferring of a peerage of the United Kingdom on Sir Joseph Benjamin Robinson, we desire to associate ourselves with the protest that has arisen in London and South Africa. Of late years His Majesty's advisers have not always shown perfect judgment in recommending the bestowal of honours, and have in consequence somewhat severely tested the loyalty of the Overseas Dominion.

IT was no small task to find a suitable successor to Sir Alfred Keogh, who retires this year from the position of Rector of the Imperial College of Science and Technology. Fortunately the trustees have been able to secure the services of Sir Thomas H. Holland for this position, and he is to assume control on September 1. Sir Thomas was a student of the Royal College of Science, and public positions which he has occupied have been the directorship of the Indian Geological Survey and the professorship of geology in the University of Manchester. More recently he showed fine administrative ability as a member of the Council of the Viceroy of India. What was India's loss, when Lord Reading quarrelled with him last year, is the Imperial College's gain.

MANY people in this country are mystified by the word "wild-catting" as applied to prospecting for oil. The term "wild-cat," denoting an unmitigated swindle, was originally introduced from America many years ago, and it has been accepted here ever since in that sense. But the meaning of words moves fast in America, like most things there, and it is necessary to note the modern American meaning of "wild-catting" as applied to oil. At first it no doubt meant an indiscriminate sinking of wells in untested lands, but at the present time it is applied in a strictly honourable sense to speculative sinking at places where the geological indications are favourable to the extension of a known oil-field. Thus "wild-catting" is nowadays very far from being a term of opprobrium; rather is it a sign of someone having the courage of his convictions. It is advisable to bear this meaning in mind when, for instance, reading the advertisements of reputable American firms who specialize in sinking for oil.

IN this issue we publish a paper by Mr. W. M. Mordey, a well-known electrical engineer, who describes a new method of magnetic concentration. This method has not yet got past the experimental stage, but its possibilities are already recognized as being very important. It is not necessary here to discuss the principle involved, for this is clearly set forth in the paper. Suffice it to say that by means of an alternating current certain feebly magnetic particles can be made to move sideways out of a freely flowing pulp. The magnet is not in contact with the pulp, and there are no moving parts. Mr. Mordey does not claim a universal application of this method, but it seems fairly clear that it will prove useful in concentrating phosphatic magnetites and hematites which have not been amenable to magnetic concentration hitherto when in the form of a pulp. It is of interest to know that much of the experimental work in connexion with this process has been done at the Royal School of Mines, where Professor Truscott and Mr. Bernard W. Holman have made many investigations and tests.

IN our article last month recounting the proceedings at the annual meeting of the Institution of Mining and Metallurgy, we omitted to record an incident that really deserved special mention, namely, the presentation of the Institution's gold medal to Mr. E. T. McCarthy. Probably the omission was due to our being so much concerned with certain personal grievances that we neglected to take note of more worthy objects of our attention. But whatever the reason, the omission was inexcusable. The bestowal of the gold medal is the highest compliment that can be paid by the Institution, for it constitutes an acknowledgment of great services rendered to the mining profession by the recipient. Everybody knows why Mr. McCarthy deserved the gold medal. It is because he has a long record of sound and unbiassed judgment, not only on matters pertaining to mining, but on things in general; because he is one who never considered it too much trouble to give well-considered and helpful advice when approached by the individual or the corporate body ; one who is loth to believe evil of his fellows, but can be righteously indignant should occasion arise. He unconsciously proclaimed his own character in acknowledging the medal, when he said : " The expressions of regard are not confined to one side, for I have the greatest admiration, and, indeed, affection, for my brother engineers. I know of no other body of men among whom so much bonhomie, such real fellowship, such good comradeship is found, as among the members of our profession." How could even the weakest of us be anything but genial and kindly in Mr. McCarthy's presence or under his influence ?

CONTINGENT fees formed the subject of a judicial statement in the course of a lawsuit last month. The details of the case are not of any great interest, nor was the result of the action, so particulars need not be given. It transpired in the course of the case that a mining expert was asked to report on a coal property in France. He was to be paid 500 guineas in cash, and he was to have a further £1,000 in debentures or shares if a company was formed. Of course, the company could not be formed unless the report in question was favourable. Mr. Justice Coleridge's comment was : " I must here express my cold disapprobation of the whole system of paying eminent engineers for their reports by results. Investors are entitled to assume that such reports are uninfluenced in their terms by pecuniary consideration. Such a mode proffers the strongest inducement to produce a favourable report, whatever are the facts. It is rather difficult to believe that a man with a character for honesty and accuracy would consent to act on such terms. The strictest integrity could resist the influence, but it would require a firmness of mind and a strength of character which are rare attributes." We would add that even though a man might write a perfectly unbiassed report under such circumstances the very fact of these circumstances would always throw a doubt on his reliability and the soundness of his methods. The whole subject of contingent fees is, of course, perfectly well known to the profession, but it is advisable to quote his lordship's remarks in order to show how the matter strikes the legal mind.

AT the meeting of the Institution of Mining and Metallurgy held on May 25 the proposals contained in Mr. H. R. Sleeman's paper on the " Re-establishment of the Gold-Basis of Currency " did not receive any support, so we may take it that any suggestions for the modification of the price of gold by statute are now relegated permanently to the background, if not entirely subverted, as far as this country is concerned. Among the speakers at the meeting were representatives of finance as well as of the mining industry. It was pointed out that no Government can vary the value of gold at will ; that is, it cannot make a smaller value of gold do the duty previously done by a larger amount. If such an idea were once granted, there would be no limit to which the debasement could be carried. Another advantage of the fixed value of gold currency is that it affords an effective check on the extravagance of a Government, for it is clear that if all expenditure has to be covered on a gold basis there is a very definite limit beyond which expenditure cannot go. It was further pointed out that the causes which have provided a premium for gold have at the same time operated to decrease its production, owing to the high prices of goods and labour under a debased currency. Get gold back to par on the market, and wages and materials back to normal, and the mining for gold will once more revive. Things have righted themselves substantially in this country since Mr. Sleeman first contemplated writing his paper, and the improvement continues to be steady if slow. In Australia the masses are beginning to condemn the Labour Party's scheme for creating wealth out of nothing, as is evidenced by the defeat of the party in New South Wales. France, Italy, and Belgium, which are in a far worse financial position than Great Britain as a consequence of the war, have expressed their determination to struggle back to par. As for the other countries, such as Austria and Poland, they can never recover until the others have done so, and then only with the help of the others. One of these days Germany and Russia will repent themselves of their financial folly, and then their cases may be considered. In conclusion we may urge that the sooner gold gets back to par, wages and costs fall, and work becomes more efficient, the sooner will gold mining and metal mining generally get on its legs again.

Flotation and the Porphyry Coppers

The welcome news is to hand from the United States that the long-continued legal dispute between Minerals Separation and the Jackling group of "porphyry" copper mining companies is to be settled out of court. The terms of the agreement have not been published, and it is not necessary that they should be, for they will partake of the nature of an ordinary business arrangement which concerns only the two contracting parties. But this withdrawal of litigation is of wide interest in mining circles in so far as it affects the general policy of protection by patent and the interpretation and discussion of inventions by men familiar with the matters in hand. The late Mr. John Ballot, head of Minerals Separation, fought tenaciously for the legal rights of his company, when the parties with whom he proposed to do business showed signs of disputing them, though his terms to those who sought a contract were far from onerous. This is exemplified by the favourable agreements with Anaconda and the Phelps-Dodge group on one hand, and by the bitter litigation with Butte and Superior and with the Jackling and Miami companies on the other. It would have been very much better if all legal action had been avoided and the matters in dispute adjudicated by arbitration within the profession, for it is fairly obvious that lawyers and judges have little or no actual knowledge of the problems involved. Decisions have usually been made on restricted arguments and on evidence picked according to the personal predilection of the individual legal adviser. Perhaps it is a Utopian dream to imagine a professional court of arbitration, and, moreover, though the litigation in these cases has been protracted and entangling, the general sentiment has been favourable to the judgments given. So our comment and suggestion on this point may not carry much weight. The two lawsuits in America took different lines, that against Butte and Superior discussing the interpretation of the small proportion of oil, and that against the Jackling and Miami companies being concerned with the method of introducing or creating the buoying bubbles. The first-named action was settled adequately by the Supreme Court, but the latter has never gone to this Court, and the decision of the Appeal Court in favour of Minerals Separation was not completely unanimous on all points. It was said at one time that Mr. Jackling had since acquired other earlier patents on the off-chance that they might prove helpful in further litigation, but of this we have no recent information. This lawsuit involved the interpretation of the action of the Callow cell, with perforated bottom, through which the compressed air is introduced, and it also included the question as to what is a soluble frothing agent. While no doubt Mr. John Ballot would have proceeded fearlessly with the fight, it can easily be imagined that the other directors have been glad to be quit of litigation and to meet their opponents with diplomatic mind. But, as we have said, the settlement concerns the mining profession chiefly because it clears an important process from the clutches of the law, and will leave the proprietary company free to discuss details in public. Concentration by flotation is only in its youth, and there is still much to be discovered relating to the principles involved and to their application in each individual case. The settlement undoubtedly is acceptable for the chances it gives for further progress.

The Imperial Mineral Resources Bureau

The publication of the annual report of the Imperial Mineral Resources Bureau for the year 1921, together with the issue of monographs on some of the principal metals, draw attention once more to this important new Department of State. The first year or two of the life of a new venture of this kind is largely occupied with preliminary arrangements for the establishment of avenues of inquiry and methods of collection of facts, so that its success or otherwise cannot well be gauged at first; nor has it been possible to form a judgment on this matter by perusal of the brief reports that have been already issued on the minor metals and minerals. Now that the reports on gold, copper, lead, tin, and platinum have been published, we are better able to assess the value of the work done and to form an idea of the eventual service to be rendered by the Bureau. After having gone through the reports named, we need only say that we are impressed with the completeness and compactness of the information. Only those who have had personal experience in the collection of statistics of occurrence, production, and consumption of metals and minerals can fully appreciate the difficulties to be surmounted. In the first place the literature on the subject is widely scattered and imperfect. Then, in many cases, the producers are not keen on supplying information which they, rightly or wrongly, consider confidential and partaking of the nature of the trade secret; for instance, the producer of pyrites cannot well be asked to give full details of the methods of handling the market, nor should the owner of a soapstone mine be necessarily expected to tell the world the various uses of this mineral. Further troubles arise by the action of well-informed parties who will not divulge their experience, but content themselves with mysteriously hinting that they know everything and that the other fellows don't. Those who are fully alive to such difficulties as these will be the first to recognize the general excellence of the reports prepared by the Bureau.

Of all the reports here mentioned, that on gold will probably be of greatest interest, so it will be convenient to take this as a type of them all. The volume occupies 370 closely printed octavo pages. The first few pages give a brief outline of gold, its compounds, and mineral associations, its occurrence in the rocks and gravels, the processes of extraction and refining, and the methods of marketing, including a discussion of the premium. Then comes a section on the gold production of the world, with many analytical tables. The main part of the book gives specific information about each gold-producing country, firstly within the British Empire, and then in the other parts of the world. Under the heading of each country, all available statistics are given, the general geology is described, and particulars are presented of the individual districts and of notable mines. Naturally the descriptions are brief, but they are concise and effective. A final chapter gives references to the chief books, articles, papers, and official reports issued during the last ten years or so. The volume covers the years 1913 to 1919, but in most cases, where the figures and information are available, the years 1920 and 1921 are also covered. It is remarkable how many countries have the note "figures not available" in the columns for 1920 and 1921. In the MAGAZINE for April we referred to this difficulty of obtaining official information or even a reasonably dependable estimate. In many cases it is probable that outputs of workings are never declared, and that the gold is lodged in banks or with dealers and merchants without any public record being made, with the consequence that the returns are incomplete and delayed. Thus neither private individuals in London or New York nor official bodies like the Bureau and the United States Mint obtain exact information, either promptly or belatedly. The United States Mint permits itself to make cautious estimates of the missing figures, but the Bureau does not undertake the responsibility of such calculations to any extent, at any rate for the present.

With regard to the personality of those chiefly responsible for the presentation of these reports, Mr. H. F. Marriott's name is given in the volume on gold as chairman of the Advisory Technical Committee on Gold. Credit is given in the volume on tin to Professor Thomas Turner, W. E. Moulsdale, and R. Arthur Thomas, and in the volume on copper to Dr. F. H. Hatch. We should like to add to these names that of Mr. Thomas Crook, a prominent member of the regular staff. To these gentlemen we extend specifically the thanks implied in the foregoing paragraphs. Another matter remains for mention, namely, the forthcoming issue of a report on the iron ore resources of the world. This will, it is believed, constitute by far the most important work on the subject ever issued, but of this we shall be better able to speak when the volumes now in the press are issued in the course of a month or two.

Mining Education

At the annual dinner of the Royal School of Mines Old Students' Association, held in London last month, the discussion centred largely round the refusal of the Government to grant University status to the Imperial College of Science and Technology. It so happens that the current issue of the MAGAZINE contains a paper by Dr. Victor Alderson, head of the Colorado School of Mines, dealing with the modern American ideas of education for the mining engineer and metallurgist, and it is convenient to take his paper into consideration in connexion with the discussion at the Old Students' dinner.

As we have recorded on previous occasions, the Imperial College has the offer of becoming an integral part of London University, but the governors, staff, and students, both old and present, have a rooted objection to accepting this proposal, claiming that the College is of sufficiently high standing and wide repute to warrant its conversion into an independent University, and at the same time objecting to the trammels likely to be imposed on the curricula by boards or committees not fully conversant with the requirements of the mining engineer. With regard to this latter argument, we believe the objections are due to misapprehensions, and would be removed by a careful examination of the London University Calendar. For instance, the University courses for science degrees are widely descriminating, and already provide among other things a course covering mining and metallurgy. This mining course in no way differs from the course at the Royal School of Mines. It is devoted entirely to the immediate subjects and the collateral sciences, and makes no mention of English literature and history or of such things as Latin, though in some of the examinations the student has to show that he can write an English essay. The requirement in subjects outside the special studies comes in Matriculation examination, in which English language, literature and history, and geography are compulsory subjects, and in which one of a wide choice of foreign languages is required. The fact that the Imperial College is a recognized school of the University indicates that the University authorities consider its courses suitable for preparation for their degrees. Another argument which seems to us erroneous alleges that the London University is a mere county affair, while the Imperial College draws students from all parts of the world. As a matter of fact, London University attracts men from just as wide a constituency, and its examinations are held in many centres besides London, both at home and abroad. From the above considerations it will be seen that certain of the objections are not really valid. There is one objection, however, which carries real weight among mining men ; that is the probability of the extinction of the "A.R.S.M." These letters are far more distinctive than the "B.Sc.", for they denote the college and the particular branch of science to which they refer ; and the fight against any proposal which involves their abolition is naturally a whole-hearted one. On the other hand, this objection does not appeal to the other branches of the Imperial College, where it is found that the objection to absorption by London University is just as uncompromising, so any suggestion on our part that London University might retain the "A.R.S.M." would be useless. The opposition to the substitution of "B.Sc.' for "A.R.S.M." goes further than we have suggested, for there is a desire that the degree should be "E.M." The whole matter is in the nature of a deadlock at present. There seems an irremovable objection to joining London University and an inflexible intention to remain as a college rather than submit, though at the same time the College continues to seek Government recognition as being worthy of becoming an independent Imperial University. It does not appear that advice on our part to join London University will bear any fruit, so we will instead recommend the present student at the School of Mines who desires a degree to take the examination for "B.Sc. London" as well as that for "A.R.S.M."

Turning now to Dr. Alderson's paper, we ought to say at the outset that he is one of the educationists and professors at the Colorado School of Mines who have weathered the political storms which have done serious disservice to an admirable institution. Without doubt his influence has been great in gradually bringing the school to a University level and in converting it from a place where current mining and metallurgical practice could be learnt to a centre of study of general principles. The present entrance examination calls for a fairly good knowledge of English and American literature and history, and throughout the whole course the study of the English language forms a necessary part of the curriculum. The same tendency has, of course, been noticeable in other technical colleges and schools in the United States during the last twenty years, and the modern American graduate in science is usually a gentlemanly well-informed fellow.

Another of Dr. Alderson's points is that the courses of study should be elastic so as to meet the requirements of the individual, so that after the first two years of general study there is now a wide range of optional subjects. His argument is that the "average student" is a myth, so that an "average" compulsory course is unworkable in practice. Moreover, he sees the danger of overcrowding a mining course with too many subjects, though admitting that the mining engineer has to have a wider and more varied knowledge than members of any other profession. We have, perhaps, said enough to draw attention to Dr. Alderson's paper. On another occasion we hope to give a more detailed account of the work done at Golden, Colorado.

REVIEW OF MINING

Introduction.—The settlement of the dispute in the engineering trades should help in the revival of business and induce a more healthy demand for metals. The gradual improvement in dollar exchange is another sign of a return to normal conditions. The Genoa Conference has been described by the daily press as a failure; certainly it ended in nothing very tangible. Mr. Leslie Urquhart, whose knowledge of Russia is unrivalled, takes a different view, and has publicly declared that the Communists have had a salutary lesson, and therefore that the Conference has been to that extent successful. The settlement of Russia on a sound economic basis, the desire of so many mining men, may thus be considered to have been brought nearer.

Transvaal.—The statistics pages and the News Letter from South Africa contain information as to the resumption of gold mining and the investigations into the economic conditions. As regards coloured labour, it will be seen that the number employed at the end of April was 138,277, as compared with 177,836 at the end of December, so it is clear that many of the 60,000 repatriated workers have been rapidly brought back again. The white force was reported toward the end of May at over 15,000, as compared with 19,000 before the strike, and more will be re-engaged as the coloured force is increased. The managers are rejecting white men known to have been troublesome, and are taking care that no one is paid over the new minimum wage unless he really deserves the increase.

Negotiations with the Union Custodian of Enemy Property with the object of buying ex-enemy shareholdings in South African mines have at last been concluded, and announcements have been made by most of the houses with regard to their purchase of these holdings. In some cases the shares acquired will be offered for sale, and in other cases they will be bought by the individual companies and cancelled. The removal of this incubus will be a factor in clearing the way for better times. The probability of many companies declaring dividends for the first half of 1922 has also strengthened the market.

The yearly reports of many of the controlling houses have been issued during the past month, but as references have already been made to the results of the individual subsidiary companies it is not necessary to review them here. But we may mention, as typical cases, that the Central Mining and Investment Corporation made a profit of £314,356 and distributed £255,000, at the rate of 12s. per £8 share, and that the profit of Rand Mines was £518,671, and the dividend £372,049, at the rate of 70%. The Central Mining figures were not much lower than those for 1920, but Rand Mines shows a considerable fall, owing to decreased dividends from the mining companies and the shrinkage in quotations. With regard to Central Mining, it is announced that Mr. H. F. Marriott has resigned as consulting engineer in London, a position he has held for eleven years. Altogether he was in the service of this group for thirty years. The shareholders will unite with the directors in their expression of regret at the severance of such a long association.

The Geduld plant is to be increased so as to bring the capacity from 40,000 to 65,000 tons per month. The new plant is to consist of 40 heavy stamps and a slime treatment installation, the sand treatment being omitted. It will be remembered that at the beginning of the year the ore reserve position was so favourable that an increase in the capacity was consequently foreshadowed. The statement now issued mentions that the current development provides ore at the proposed increased rate of extraction; also that with the greater scale of treatment and with the lower wages cost it will be possible to include 2½ million tons in the reserve that has not hitherto been taken into consideration. At December 31 last, the reserve was given at 3,545,000 tons averaging 8·1 dwt. per ton; the figures obtained by including this low-grade ore are 6,000,000 tons averaging 6·6 dwt. per ton.

Belgian Congo.—At the annual meeting of the Tanganyika Concessions, Mr. Robert Williams gave one of his comprehensive surveys of the progress of the mining operations conducted in the Congo Territory by this company and the Union Minière du Haut Katanga. The copper output of the blast-furnaces during 1921 was 30,470 tons, the monthly figures showing gradual recovery from 1,322 tons in January to 2,980 tons in December. The concentrator, with a capacity of 4,000 tons per day, has been completed, and the first unit started in July last. The test leaching plant involving electrolytic precipitation started running in November, and has already demonstrated that this provides the best process for treating the low-grade ores. Plans are in hand for the erection of hydro-electric current, but the discovery and development of extensive coal deposits at Sankishia, 200 miles to the north of Kambove, may have some influence in varying the plans when an extension is contemplated. The availability of this coal is also likely to modify the smelting methods, and a reverberatory furnace of large capacity is already in course of erection, in which powdered coal is to be used. The figures for reserves show enormous resources. In twelve workings in the eastern groups 49,000,000 tons is estimated to average 6% copper, and in the western group a preliminary estimate gives 20,000,000 tons averaging 8 to 9%. Of other metal enterprises of the company, that in connexion with tin is assuming importance. Over 1,000 tons of tin concentrate had been extracted by the end of December, and the monthly output is now about 50 tons. Mr. Williams also mentioned work done on the Ruwe gold and platinum deposits and on nickel, cobalt, and uranium ores. In order to provide funds for the new copper plants, the Union Minière is raising 300,000,000 francs by the issue of new shares, and Tanganyika Concessions is taking its quota for that purpose, increasing its capital by 1,300,000 shares of £1 each to be issued at such time and at such a price as may be decided. Another part of Mr. Williams's address dealt with the Benguella railway, which is to connect the mines with the west coast of Africa. With the object of securing further capital for the completion of this railway, application was made to the Trade Facilities Committee for the guarantee of £3,000,000. An unexpected opposition to this proposal has been received from the Government of the Union of South Africa, which is at present negotiating with the British South Africa Company with regard to the possession of the Rhodesian railways should Rhodesia come into the Union. There are certain rights involved in connexion with the building of the Benguella railway which have to be settled, and in the meantime progress is blocked.

Rhodesia.—The output of gold during April was reported at 45,318 oz., as compared with 54,643 oz. in March and 47,858 oz. in April, 1921. Other outputs from Southern Rhodesia during April were: Silver, 14,847 oz.; coal, 37,469 tons; chrome ore, 2,815 tons; copper, 295 tons; asbestos, 940 tons; arsenic, 96 tons; mica, 12 tons; diamonds, 32 carats.

West Africa.—The official figure for the output of gold in West Africa during 1921 is 203,395 oz. Other returns for the year were: Manganese ore 7,195 tons, and diamonds 1,789, valued at £4,476.

At the meeting of the Fanti Consolidated Mines, Mr. Edmund Davis announced that the contract for the sale of manganese ore, particulars of which were given a year ago, had been cancelled on account of the difficulty in agreeing as to what was a profit. The company is now undertaking the development and equipment itself, and it is hoped that shipments at the rate of 70,000 to 100,000 tons per year will be effected shortly. The deposits are situated favourably for the English and American markets, and the ore commands a premium. On the other hand, the short haulage to the coast is unduly expensive, and the facilities for transfer to ships are poor, but these drawbacks are being gradully removed.

Nigeria.—The prospecting plant for testing the gold lodes at Birnin Gwari, where property was acquired last year by the Naraguta (Nigeria) Tin Mines Company, has been erected and started work at the latter end of last month.

Australia.—Mr. Arthur Francis, local director of Hampton Properties and Hampton Gold Mining Areas, is in England at present consulting with the board of the former with regard to developments and provision of plant. The company has three promising properties, two on Block 50 and one on Block 45. It has been decided to postpone further work on Block 50 and to concentrate on Block 45. A treatment plant with a capacity of 1,000 tons per month is to be erected, and the profits obtained are to be devoted to development in depth. At the present time the water level at 168 ft. is the deepest point.

Great dissatisfaction is prevalent in West Australia with regard to the State Arbitration Court's recommendation of only 1s. a day on gold miners' wages. This reduction is held to be quite insufficient, and many companies will be rendered anxious as to their future.

During the year 1921, the period covered by the report just published, no work was done at the mine of the Zinc Corporation, and operations were confined to the treatment of old zinc tailing. The amount sent to the flotation plant was 380,040 tons, averaging 16·1% zinc, 5% lead, and 4·9 oz. silver per ton. The products were 104,215 tons of zinc concentrate averaging 48·1% zinc, 7·3% lead, and 9·2 oz. silver, together with 9,095 tons of lead concentrate averaging 56·8% lead, 15·8% zinc, and 23·4 oz. silver. There were also produced 874 tons of lead slime averaging 40·5% lead, 17·7% zinc, and 39·6 oz. silver, and 9,166 tons of zinc slime averaging 35% zinc, 14·7% lead, and 18·3 oz. silver. The zinc slime was stacked for future treatment. The ore reserve in the mine is estimated at 2,115,700 tons averaging 14·6% lead, 9·4% zinc, and 2·6 oz. silver. This does not include any ore in the zinc lode. The zinc tailing remaining in the old dumps is estimated at 340,800 tons. The income from the sale of the zinc concentrate to the British Government, and the sale of the lead concentrate and slime on the market brought a provisional revenue of £404,845, and the 20% preference dividend was paid absorbing £49,138.

The Badak incident will no doubt be remembered; a Malayan tin property was boomed in Melbourne, and subsequently proved to be valueless. The discoverer and two directors of the company were prosecuted for conspiring to defraud. Cable news is now to hand that this prosecution has failed and that the accused were acquitted.

No definite technical statement has been made as to Mr. John Fell's method of distilling oil-shale *in situ* without mining, except that he has started the process at the mines of the Commonwealth Oil Corporation. We cannot do more than quote the following from the speech of the chairman at the shareholders' meeting last month: "Perhaps the subject upon which the shareholders were most anxious to have some information was the experiment that had been conducted during the last eight months with Mr. Fell's process for retorting *in situ*. What Mr. Fell did was to use the entire mine as one huge retort. When the fire was lighted up in the middle of August a quantity of oil was obtained, but, unfortunately, troubles overtook the production." We await a technical account of this method.

Burma.—Particulars of the Premier Oil Company's new venture in Burma are now to hand. It will be remembered that the company sold its Galician and Czecho-Slovakian properties to a French company, receiving a large sum in cash as well as shares. The new policy is to undertake drilling work on the property of the Indo-Burma Oilfields, as outlined in our last issue, on a co-operative basis, and in addition the company has secured oil rights over other areas. The first work to be undertaken is the sinking of two wells in the Indo-Burma company's Padaukpin area.

Malaya.—The Malayan Collieries, Ltd., operating at Batu Arang, Selangor, reports an output of 472,859 tons of coal during the eighteen months ended December 31 last, and a profit of £150,037. The company recently acquired a coal property at Pamoekan Bay, in south-east Borneo, from Dutch owners. The output from this property is not yet large, and only development coal is being sold, but an output of 10,000 tons per month is expected by the end of 1922. It is reported that even the second grade coal on this property is better than any other coal found in Borneo, while the best quality is equal to the best Australian coals.

Several reports of mining companies operating in Perak have been published during the past month. The Pengkalen announces that the new electric plant has been brought into commission, and that the company has been thus able to extend its sales of electric current. Also the dredge is nearly complete, so that the company will once more be engaged in mining within a short time, instead of being merely a seller of power, as has been the case during the last few years. At the Idris company's property 201 tons of tin concentrate was recovered, and a profit of £2,433 was made, out of which a dividend of 6d. per share was distributed. The yield was lower than usual owing to ground below the average of the property being worked. At the Sungei Besi the output was 607 tons, the profit £3,522, and the dividend 5%. This company has recently acquired further ground, which has been proved to be of considerable value by boring.

Cornwall.—As briefly mentioned last month, South Crofty has received Treasury support to the extent of £30,000 on the advice of the Trade Facilities Act Advisory Committee. In reviewing the history of Cornish attempts to obtain financial aid from the Government for the tin mining industry during the last year or so, it becomes obvious now that there has been a wide misunderstanding of the matter in all quarters, owing presumably to those in authority to advise the Government having no power to indicate the nature of the schemes which would receive their support. There was a generally prevalent idea that no scheme would pass unless all the producers in the Camborne-Redruth area agreed to a joint plan. Acting on this supposition, an effort was made to find common ground for East Pool and South Crofty in the matter of the pumping question, but, as already recorded, no agreement could be reached between these two companies. East Pool settled the matter by sealing off their old workings and sinking a new shaft, a plan which unfortunately terminated the aid given by East Pool to South Crofty in coping with the water coming into both mines. Thus it became necessary for South Crofty to increase its pumping installation. Taking its courage in both hands, the South Crofty board approached the Trade Facilities Committee and asked for a loan or Government guarantee of £30,000. Much to most people's pleasurable surprise the Committee readily acceded to the proposition, and South Crofty is now able to borrow the money from its bank as and when it is required. It is not necessary to enter into details here, as these are clearly stated by the chairman, Mr. Francis Allen, and Mr. Josiah Paull, the manager, in their addresses to shareholders reported elsewhere in this issue, but we may remark that the Government is evidently open to consider any definite and agreed scheme, and there is strong hope that this aid may be forthcoming in one or two other directions.

Scotland.—It is announced that the D'Arcy bore sunk near Dalkeith by Messrs. S. Pearson & Sons, under Government auspices, has intersected oil-sand at a depth of 1,810 ft. Mr. J. E. Hackford's report shows the oil to have a paraffin base, a specific gravity of 0·819, and to contain 15% petrol, 25% kerosene, 35% gas oil, and 25% lubricating oil. It will be remembered that the other Scottish bore at West Calder gave no results.

Canada.—Steps are being taken to convert the Keeley Silver Mines, Ltd., into a Canadian company; applications have been made to the High Court, and a meeting of shareholders is to be held. It is intended that five shares of one dollar each in the new company shall be given in exchange for each 10s. share of the present English company. The reason for this change is that Canadian shareholders are prepared to subscribe additional capital for the purpose of extending the operations.

The first return issued by the Kirkland Lake Proprietary relating to the results obtained at the reopened Tough Oakes mill records an extraction of $19,000 from 2,040 tons of ore for the period to May 24.

United States.—The use of the diamond-drill in oil prospecting is attracting much attention in mining circles. The United States Bureau of Mines has sent one of its oil experts, Mr. F. A. Edson, to Texas and California to investigate the results obtained, and he is preparing a bulletin on the subject to be published by the Bureau.

Argentine. — The Argentine Oilfields, Ltd., has been formed in London to acquire oil lands in the Neuquen district from the Compania Petrolera de Cerro Lotena. Mr. Campbell Hunter has reported favourably on the prospects. The geological formation and an adjoining outcrop of oil-sands give cause for believing that oil similar to that produced at the Government wells at Plazo Huincal will be found on the lands acquired by the company.

Peru.—Another attempt is to be made to work the old San Antonio de Esquilache lead-silver mine, high in the Andes near Puno. The attempt to raise further capital according to the scheme outlined in our issue of March, 1921, did not come to fruition. According to the new plan Messrs. James Brothers become consulting engineers and Mr. W. H. Trewartha-James has been appointed chairman. The company is being reconstructed as the Southern Peruvian Mines, Ltd., with a liability of one shilling on 500,000 shares of five shillings each.

Colombia.—As recorded in January, the Tolima company, which has worked the Frias silver mine in Colombia since 1871, has been in financial straits owing to the fall in the price of silver, following serious interruptions during the war. It is now announced that the company is to be reconstructed and additional capital raised. The £1 shares are to be reduced to 5s., credited as 3s. paid. The funds thus provided will be sufficient to retire half of the debentures now due for payment and to enable work to be resumed at the mine. The other half of the debentures due for redemption will be met by the issue of debentures in the new company redeemable in three years. There will also be 100,000 shares of 5s. each in the new company issuable whenever capital can be profitably applied. In addition to the reopening of the Frias mine, it is intended to develop and test the Bruja de Margaritas property.

THE CONCENTRATION OF MINERALS
BY MEANS OF
ALTERNATE ELECTRIC CURRENTS

By W. M. MORDEY,

Past President of the Institution of Electrical Engineers; Member of the Institution of Civil Engineers.

This paper was read before the South African Institution of Electrical Engineers last December, during a professional visit by the author to South Africa. As the experimental work was done to a large extent at the Royal School of Mines, South Kensington, and as the subject matter promises to be of great interest to many engineers throughout the world, it is here reproduced in full.

INTRODUCTION.—This paper is concerned mainly with certain physical phenomena, not with developed practical processes. It is based on an experimental study which was interrupted at the end of 1920, when the author's work called him to Portuguese East Africa. The paper was put together while the author was in that country. There has been no opportunity then or since of making check tests on a number of points that have arisen during the writing of the paper, nor of consulting works of reference or other sources of information.

THE ACTION OF ALTERNATING CURRENTS ON MINERALS.—An ordinary laminated alternate-current electro-magnet behaves more or less like a permanent magnet, or a direct-current electro-magnet, when presented to a mass of iron filings or crushed magnetite, tufts of these materials adhering strongly to the poles and joining them by lines of force if they are not too far apart. These effects of alternating magnetism in themselves do not offer any advantage over uni-directional magnetism for the concentration of minerals; on the contrary, they involve a greater expenditure of energy —and at a low power factor—for the production of a given field. But if we carry our experiments a little further we come across certain effects which may be thought of practical and theoretical interest.

Let us try some less promising material than iron or magnetite, for example, specular hematite, the black crystalline form of ferric oxide, Fe_2O_3. We know this to be very feebly magnetic; it will not adhere to a permanent magnet, but will do so to a powerful direct-current electro-magnet. It is so feebly magnetic that it has only been separated from its gangue, with great difficulty, by specially designed powerful magnetic separators. If we plunge the poles of an alternate-current electro-magnet into a quantity of this material, we do not find that any of it adheres to the poles. This excites our suspicion, so we set the magnet with its poles upward, sprinkle a little of the finely crushed ore on a glass dish over the magnet, and find that the hematite particles are not attracted, but are actually repelled from the poles in every direction. On tapping the dish gently any gangue that may be present collects gravitationally at the bottom of the dish, and the heavier hematite is repelled up the slopes of the dish away from the poles. By using a mixture of specular hematite and silver sand we are the better able to see that the concentration is practically complete. With some other ores or materials of known feeble magnetic properties we get similar effects, but we will confine our attention mainly to specular hematite, for the present.

As this substance is feebly paramagnetic by all the usual tests and definitions, it at once occurs to us that the effect we have observed may be due to the repulsion of eddy currents induced in the particles by the alternating magnetism; but we do not feel much confidence in that supposition when we consider the high specific resistance of the material and its extreme subdivision, and we finally dismiss the eddy current supposition altogether when we find no movement even with finely divided aluminium—a metal of very low specific resistance—on putting it in the place of the specular hematite, or with clean polished lead shot, resting on a flat sheet of glass. So we make another little experiment. On a flat glass plate resting on the alternate-current magnet, we place a small heap of crushed specular hematite on the middle of the space between the poles and, tapping the plate gently, the heap slowly elongates at right angles to the magnetic axis; that is to say, the material feebly but unmistakably takes up the equatorial or diamagnetic position (see Fig. 1). Thus this mineral, which is paramagnetic with uni-directional magnetism, appears to be diamagnetic with alternating magnetism.

In seeking for explanations of this effect, we have three properties to consider: electrical conductivity, magnetic susceptibility or permeability, and magnetic hysteresis. Having dismissed conductivity as inadequate (it would cause repulsion if appreciable), we turn to permeability and hysteresis, and ultimately realize that with

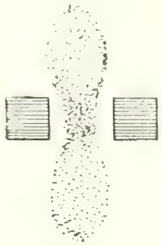

Fig 1.

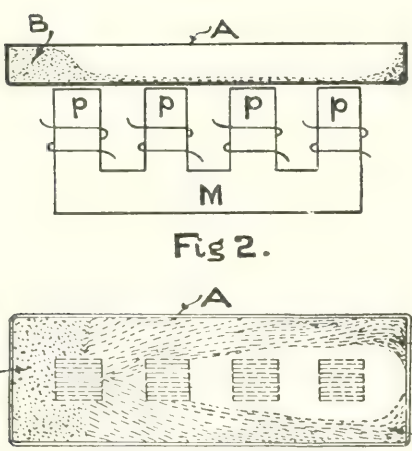

Fig 2.

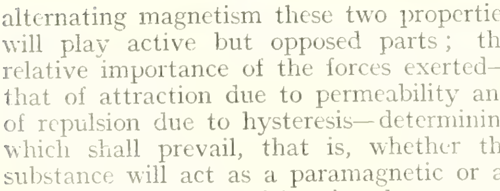

Fig 3.

alternating magnetism these two properties will play active but opposed parts; the relative importance of the forces exerted—that of attraction due to permeability and of repulsion due to hysteresis—determining which shall prevail, that is, whether the substance will act as a paramagnetic or as a diamagnetic material; in the present instance hysteresis prevailed.

But we must not conclude that there will always be this dual action, that specular hematite will always act in the manner described with alternating magnetism. That will depend on the frequency; by decreasing or increasing the frequency hysteresis may be reduced or, in the latter case, eliminated (as will be shown presently), when repulsion will cease, the apparently diamagnetic changing to paramagnetic.

In studying this subject we naturally recall Faraday's original researches on diamagnetism; all his results were obtained with uni-directional magnetism, and all his explanations and definitions had reference to that. There was only one partial and accidental exception, the record of which is characteristic and interesting. When he suspended a pellet of silver, by a silk fibre, near the poles of his electro-magnet he noticed that when he made or broke the circuit of the magnet the pellet was momentarily repelled from the magnet. He investigated that, and proved that the repulsion was not due to diamagnetism, like the repulsion of a pellet of bismuth, but to eddy currents. As Faraday would not apply the term diamagnetic to an effect other than that for which he had introduced that term, it will probably be agreed that it ought not to be applied to still another kind of repulsion. In the present paper that other effect is attributed to hysteretic repulsion.

So far, we have used an ordinary laminated horse-shoe electro-magnet, excited by a 1-phase current at fifty periods a second. The induction used was low, probably about 2,000 B in the core, and yet the poles exerted an appreciable repulsion through a distance of several inches. These results encourage us to proceed a little further with our experiments.

Let us now try a multiphase magnet, for instance, a multipolar magnet (M, Figs. 2 and 3), made like a narrow portion of a toothed armature or field, laid out flat with the poles or teeth pointing upwards. In the space above the poles p of such a magnet, when magnetized by multiphase currents, waves of an alternating magnetic field will sweep along continuously, in one direction or the other according to the connexions of the windings, at a speed depending on the frequency and on the spacing of the poles. Resting on the poles of this magnet place a non-conducting dish A, in which put a heap B of the material to be tried, such as crushed specular hematite ore. On exciting one phase at any usual frequency, such as 50, the magnet will act very much like the 1-phase magnet previously used, the particles of hematite being feebly repelled in every direction from the poles.

But on exciting the second phase a different and stronger action takes place, the hematite streaming from the heap B towards the end C of the dish, avoiding the poles, and curving out towards the sides of the dish, as shown in Fig. 3, collecting mostly at the two right-hand corners of C, the middle space at the end being left there. This migration of the particles is slow but steady (from one to three inches per second in this experiment), the rate being the same whether passing over the poles or over the spaces between or at the sides of the poles ; there is no visible polar action and no deflection towards the poles. If the heap B consist of a mixture of silver sand or crushed quartz and specular hematite the particles of the latter will be clearly seen emerging on the upper surface of the heap, and then moving away horizontally, as described above, showing that these particles are repelled upwards from the magnet, with sufficient force to penetrate a light covering of dry sand, before being propelled along from end to end of the row of poles. Shaking the tray or stirring the heap greatly facilitates the action, not by increasing the speed, but by enabling the particles the better to free themselves. If a small heap of sand is placed in the path of the moving particles they will climb over it.

We see in this action the repulsion of this feebly magnetic substance from the poles as with 1-phase, accompanied by a migratory movement, due, no doubt, to the continuously advancing alternating magnetic waves, as if a succession of 1-phase magnets was being mechanically moved along under the dish.

If any iron filings or particles of magnetite are present they will stay over, or be drawn to, the poles (dancing over the poles), only moving on if the dish is raised several inches or the field weakened ; they will then advance rapidly over the line of the poles, very much more rapidly than the specular hematite, and will not be repelled to the sides.

This narrow magnet brings out certain differences. For example, with specular hematite the lateral repulsion is from the line or row of poles, not from the individual poles, and the lengthwise repulsion or propulsion or migration is parallel with, but not over, the line of poles. Whereas with iron filings or magnetite there is attraction to the line of poles, followed, if the field be not too strong, by lengthwise repulsion, propulsion or migration along and over the line of poles, not to the sides of that line.

Instead of a long narrow magnet, let us use a magnet that is roughly square in plan, as shown in Figs. 4 and 5, the winding not being shown. This can be wound with a coil round each tooth, the connexion being 2-phase. Such a magnet may be made of stampings with teeth and spaces, each about 1 in. wide and 3 in. long. A wave winding would require seven teeth for balanced phases ; it would not be so convenient for our present purpose. The outside or end poles or teeth must have a winding external to them, otherwise there will be no repulsion beyond the iron. With the magnet somewhat as shown in the figures, and using a dish that is not greater in width than the magnet, the material—for example, specular

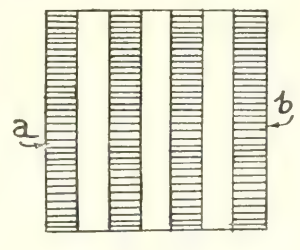

Fig 4.

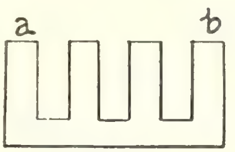

Fig 5.

hematite—will not tend to escape sideways, and as the lateral repulsion will be balanced, will pass over the poles in a steady and nearly uniform stream of particles, from *a* to *b* or vice versa. Although there is no evident lateral repulsion, there is no doubt a vertical repulsion, which will aid mobility and have other effects to which reference will be made later. With such a magnet we can make many experiments and tests.

It will be observed that if the material be placed a little beyond one end of the row of poles, as in Figs. 2 and 3, it—even specular hematite—will be attracted into the field, propelled along it, and repelled or expelled out of it at the other end of the row of poles. These end effects are, of course, due to spreading or extension of the multiphase field beyond the ends of the line of poles ; the apparent attraction may be regarded as a repulsion from the extended field. The whole action is directed to the repulsion of the material from the magnetic field in a certain direction, in line with the movement of the so-called rotating field. As the ultimate result is repulsion it is probably not incorrect and is certainly convenient to apply the term hysteretic repulsion to the whole series.

If we try crushed magnetite in a dish over such a magnet we find that there is no migration of the material if the dish is resting on the poles or near them, the material standing up over and joining the poles forming thin high distinct planes, plates, or laminæ, separated from each other by clear parallel spaces of $\frac{1}{8}$ in. or more wide. These planes are apparently mutually repellant. Towards the sides of the magnet they tend to lean over radially, no doubt in accord with the disposition of the field and the unbalanced repulsion. This formation is quite different from the lines of force in the field of a uni-directional magnet, or the tufting of filings or magnetite on or near the poles of either a uni-directional or a 1-phase magnet. If the dish is moved backward and forward on the surface of the magnet, the planes sway flexibly to and fro, but do not break up unless the dish is raised. These planes are parallel with the core-plates of the magnet, but there seems no reason for supposing there is any numerical relation between them. The lower portions of these planes tremble a little with the alternations, otherwise they stand erect and steady. If they are more than about $\frac{3}{4}$ in. or 1 in. high, the upper portions become unsteady, and seem to be in a state of unstable equilibrium. Small portions of the top of one or other of these planes then become detached and dart rapidly forward horizontally through the air to another part of the same plane or to the extremity of the dish, indicating that at a certain height the force of repulsion or propulsion is strong enough to overcome that of attraction and of gravitation.

The sudden change from the stationary to the migratory condition, as the field is weakened or the dish raised, can be clearly shown by raising the dish slowly and carefully, when the material will first get unsteady, and then suddenly move forward.

In water, magnetite or iron filings tend to form rudimentary plates, closer together than when dry. The tendency to remain stationary over the poles is much less in water than dry, no doubt because of the partial flotation and consequent greater mobility assisting the force of repulsion.

Perhaps we should not leave this subject without at least an attempt at an explanation. These planes of force seem to be formed in a multiphase field by a material in which magnetic attraction is approaching the condition of being overcome by hysteretic repulsion, the attraction holding the material in place, its particles tending to arrange themselves with their longest dimensions in the lines of force. The moving field accentuates this tendency, marshalling the particles in line and preventing those in one plane from setting themselves across the space to either side of that plane.

The vertical hysteretic repulsion already referred to prevents the planes exceeding a certain height in a field of given strength and frequency. Through the successive changes of the field, all points facing one another on the sides of adjacent planes are magnetically equi-potential, and, therefore, mutually repellant, this lateral repulsion separating, compressing, and flattening the planes. As the planes grow in height, the magnetic adhesion at their upper parts lessens, and hysteretic repulsion increases, till finally the tops of the planes are torn off and thrown forward by the moving field, the vertical repulsion supporting them in their horizontal flight.

In experimenting with filings it is well to remember that the "hysteretic constant" varies from 0·002 with very soft iron to about 0·016 with cast iron, and 0·025 with hardened cast steel, so the experimenter should be prepared for some irregularity in his results, unless his iron filings are chosen with some care.

As an example of differences in the action of materials, mention may be made of the behaviour of some iron kindly sent me by Professor Truscott, from the Museum of the Royal School of Mines. It was labelled, "Iron separated from Blende, after calcination, by Magnetic Separator." It was black, in coarse grains, and lumps up to about $\frac{3}{8}$ in. in diameter, with slightly conchoidal surface. It was very violently repelled across a dish resting on the surface of the multiphase magnet. If it had been placed on a flat glass sheet on the magnet, it would probably have been ejected from the field to a considerable distance. Here is a strongly magnetic material no doubt obtained by the attraction of a uni-directional magnet that is violently repelled by a multiphase magnet. It is hoped that some further examination of this substance may shortly be made. It will probably be found to be an impure form of iron having a very high hysteretic constant. This is indicated by the fact that its magnetism was not sufficient to hold it even when quite close to the poles. That the action was not due to eddies is shown by the fine and coarse material being equally affected.

From these various experiments we see that hysteretic repulsion is not confined to certain feebly magnetic materials, but is capable under suitable conditions of causing even the most magnetic materials to retreat with vigour from a strong multi-phase magnetic field.

With feebly magnetic materials the difference is very great between their speed and that of the field under the influence of which they move. In the one case the speed is a very few inches per second; in the other, many feet per second, usually fifteen to twenty. No attempt was made to measure the speed of the iron in the experiment last described, nor that of the filings nor of the magnetite in some other experiments, but their movement was certainly very much more rapid than that of the feebly magnetic materials. It is hoped to make some tests to find if there is any close connexion between the speeds of various substances and their permeability or hysteresis, or both.

John Hopkinson found that with iron the hysteresis per cycle was constant up to at least 400 cycles per second. Apparently this is not true of the iron oxides with which we are now dealing. Observations on this point were made with specular hematite, and to some extent with magnetite, the method being to observe the time particles took to travel across a dish placed over a multiphase magnet. Tests were made at 25, 50, 75, 150, and 350 periods per second, the excitation in amperes being constant. From 25 to 75 periods the speed of the specular hematite increased approximately as the square of the frequency. It is perhaps allowable to assume that if still lower frequencies had been used the movement of the material would have stopped as zero was approached (it was very slow even at 25 periods), and that magnetic attraction would then assert itself almost unopposed by hysteretic repulsion. But our object was to get greater repulsion, not less, so a higher frequency was tried. At 150 and at 350 periods there was no movement, or only a very feeble movement of a few particles (which were possibly iron), that is, no repulsion and presumably little or no hysteresis; but at both 150 and 350 periods magnetic attraction was very evident, although at 75 periods and less there had been no sign of it.

It should be mentioned that in order to have the same exciting current throughout this series of tests it was necessary to use a low core induction, about 560 B.

The note-book entry on the experiments at the two higher frequencies was as follows: At 350 periods magnetite stood up over the poles; there was a strong orientation, but no movement, except a little to the edges of the poles in either direction from the middle of a pole. This is an effect well known with uni-directional magnetism, and is due to the greater density at the edges. With 1-phase the action was the same as with 2-phase; orientation, but no movement. With black specular hematite a very slight movement of a few particles and orientation. At 150 periods no practical difference from the last experiment with either magnetite or hematite, with the latter perhaps a little more movement.

Thus it appears that, in these oxides of iron, hysteretic repulsion in a multiphase field reaches a maximum somewhere between 75 and 150 periods per second, probably not far from 100 periods; that it is practically non-existent at 150 and at 350 periods, the materials then reasserting themselves as paramagnetics.

It will be understood that the cessation of any migratory movement is not strictly a proof that there is no hysteresis, but that it is so reduced as to be unable to overcome the force of attraction.

These experiments seem to support the view previously expressed as to the dual action in an alternating field. With hysteresis eliminated alternating magnetic attraction manifests itself alone, the particles even of so feebly magnetic a substance as specular hematite standing motionless over the poles, and oriented to them, and this, be it noted, either in a 1-phase or a 2-phase field; that is to say, there is no repulsion in a 1-phase field or migration in a multiphase field if there is no hysteresis. It is hardly necessary to point out that the question of minimum energy for a given result may be of more importance than the precise choice of frequency, and it should not be forgotten that the energy is approximately proportional to the square of the frequency.

When the field of a multiphase magnet is weakened by reducing the excitation, or when the distance from the poles is increased, iron filings or magnetite in a dish over the poles, subject to exceptions as already mentioned, become migratory, although in a stronger field they remain stationary, showing strong attraction. This is what might be expected from a consideration of uni-directional attraction, which decreases very rapidly with distance, and from the Steinmetz co-efficient for hysteresis, B 1·6. But with specular hematite repulsion in a multiphase field always prevails, except at the higher frequencies; there is no laminar structure, no standing over the poles, the material moving slowly and steadily forward, much more slowly than magnetite. As the action is simple, a test was made at 50 periods to find the effect of distance on the movement of specular hematite by observing the time taken by a certain amount of the material to travel across a dish supported at various distances above the poles of a multiphase magnet. The result was as follows: $\frac{1}{8}$ to $\frac{3}{4}$ in., 2 seconds; $1\frac{1}{4}$ in., $2\frac{1}{2}$ seconds; $1\frac{3}{4}$ in. 3 seconds. Thus, throughout a considerable distance above the poles the rate of travel was sensibly constant, and even beyond that region the decrease was not very great.

As it is difficult to believe that the induction was constant through the region of constant speed, some other explanation seems to be called for. It is perhaps possible that as the induction falls off it may be counterbalanced by an increase in what, for lack of a better term, may be called the meshing of the phases; it is not difficult to form a mental picture of such an effect.

The minimum distance of $\frac{1}{8}$ in. referred to above represents the thickness of the dish resting on the poles. The result of reducing the distance to much less than $\frac{1}{8}$ in. by placing the material on a piece of note-paper resting on the poles is that the rate of travel is appreciably reduced. This affords another point of difference between magnetic attraction and hysteretic repulsion, and is perhaps not inconsistent with the explanation suggested above.

The foregoing test throws some light on the behaviour of the upper parts of the planes of force referred to elsewhere.

A brief reference may be made to a few general experiments. If the dish is open on one side, the concentrate may be driven several inches beyond the magnet, as in Fig. 6; or it may be driven over the side or corner of the dish, as in Fig. 7. If the dish is tilted at an incline of about 1 in 4, as in Fig. 8, and some specular hematite is placed at A, it will climb up several inches, and be maintained there till the excitation is switched off, when it will run back to A. This action through a considerable air space is significant.

With materials in water the effects are the same in kind as dry, but generally stronger, often much stronger, as is to be

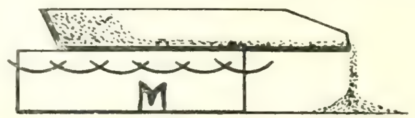

Fig 6.

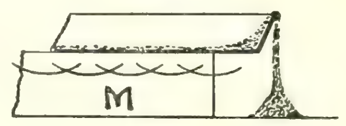

Fig 7.

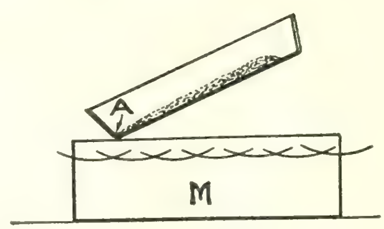

Fig 8.

expected from the partial flotation of the particles and their greater mobility. Gravitational concentration is, of course, reversed, as the heavier value acts as if lighter than the gangue. This is the case wet or dry. For example, if in a slightly tilted dish, as in Fig. 9, we place a thin pulp or slime of specular hematite ore, over the magnet M, the gangue gravitates to *a* and the heavier hematite collects at *b*. Shaking or stirring in this, as in other cases, helps the action. The sensitiveness of very fine material to the action of the magnet is clearly shown. On closing the circuit this fine material is at once seen moving rapidly forward like a cloud of ink, even without any stirring or agitation.

If a slime or fine pulp of suitable material is placed in a tilted dish open on one side, as in Fig. 10, filling it up to the line *a*, it will be found on energizing the magnet M that the concentrate and some of the water will be driven up-hill, somewhat as shown by the line *b*, overflowing at *c*, the gangue gravitating to G. As in Fig. 8, this action will take place with M horizontal; if M is tilted to the same slope as the dish the action will, of course, be stronger. The upward flow is not due to any direct action on the water, but to surface tension between the water and the concentrate. It does not occur with the gangue and water only.

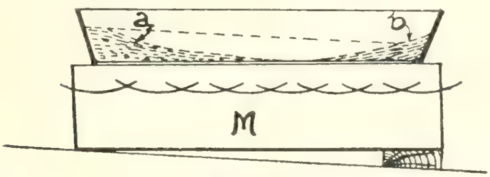

Fig 9.

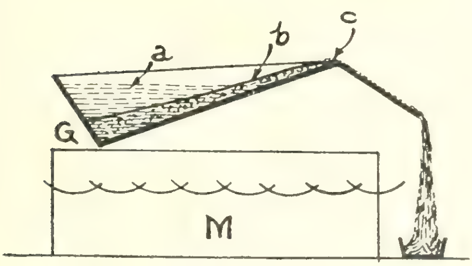

Fig 10.

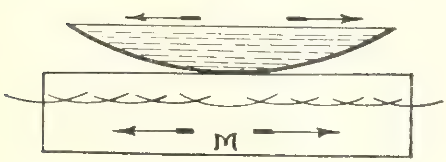

Fig 11.

By winding or connecting a multiphase magnet suitably the phases may be reversed in direction from the middle to each side, as indicated by the lower arrows on M in Fig. 11. The result of this will be that the concentrate will then move from the middle to each side, as shown by the upper arrows, and the gangue will collect in the middle of the dish, especially if the latter is slightly concave. If a small quantity of a susceptible substance is placed in a test-tube, which is then filled with water or thin, clear oil, and rotated on its axis over a magnet M, to ensure freedom of movement, as in Fig. 12, the concentrate will move along to one end of the tube, and if the tube be suitably inclined the gangue will pass to the lower end.

On finding, as mentioned earlier in the paper, that aluminium powder or grains did not show any inclination to move, either wet or dry, in a flat dish, some of it was tried in a test-tube, as in Fig. 12. On slowly rotating the tube aluminium particles were made to fall in a continuous rain across the diameter of the tube. This rain was vertical, showing that there was no appreciable eddy current effect, and there was no change in the disposition of the particles, no sign of any gradual longitudinal movement. No doubt with a very strong field there would be some movement, but the experiment shows that in a field easily capable of causing movement by hysteretic repulsion, however finely divided the material, there is no observable eddy-current effect, even in a very good conductor in the form of coarse powder or grains.

With the same excitation, in amperes per pole, of a multi-polar magnet, the speed of the material was near 50% more with 2-phase than with 3-phase. Although rather surprising at first, this is what should be expected from the disposition of the magnetic circuit.

Practical Applications and Tests.—The results described provide material for the study of possible applications to practical ore-dressing. We should begin this study by recognizing that many very good magnetic separators are in successful use, and that it would be difficult to improve on them for the kinds of work for which they have been found suitable. It will therefore be wise, for our present purpose, to confine ourselves to what we are told by the authorities is an unsolved problem, the magnetic concentration of finely divided, wet, feebly magnetic materials. Let us take such a mixture, slime or pulp, as before, of crushed specular hematite ore in water. Let it flow down a non-conducting launder or channel at such a speed that it will not settle or form banks. And let this launder rest on a long narrow multiphase magnet with longitudinal poles and windings, the arrangement in section resembling that having the field of force moving in both directions from the middle, the double-action magnet indicated in Fig. 11, or better still, in Fig. 13. Then, as the pulp flows down the launder, the hematite will move to the sides in both directions, to right and left, and if the field is strong enough, will be discharged over the sides with some of the water, or it may be assisted over the sides by small jets of water, the gangue gravitating to the middle being discharged at the end as tailing. Or, the concentrate may be allowed to flow down the two sides of the launder, the middle of the stream as before being the tailing.

Another arrangement of magnet and launder is as indicated in Fig. 9, reading that figure as a sectional view of a long launder. The magnet and launder have a slight transverse inclination to allow the gangue to gravitate to one side of the stream, while the concentrate, under the influence of the magnet, migrates to the other side of the stream; thus the two materials will follow diagonal lines that cross one another, the stream arriving at the end of the launder with the concentrate on one side and the tailing on the other, the only moving thing being the stream itself.

For a number of launders, to treat a large quantity of material, one wide magnet and launder would be used, the latter being divided longitudinally into a number of channels in order that the transverse migration in each channel shall not be more in distance than sufficient for the purposes of concentration, the small channels discharging their concentrates and tailings into appropriate receptacles.

There should be no difficulty in constructing a magnet to withstand the conditions inseparable from wet treatment, or even to work in water, as the voltage could be limited by transformation and suitably insulated cables used.

By the kindness of Professor Truscott, some tests were made in the Bessemer Laboratory with a very short magnet and launder arranged on the last-mentioned plan. The magnet was 3 ft. long and about 9 in. wide. A wooden launder about 5 ft. long and about 11 in. wide was used. On the occasion of the first trial of this apparatus a pulp of a synthetic ore consisting of one part of specular hematite and three of quartz, crushed to 60 mesh, in water, was sent down the launder, which was set at a slope of 1 in 20 with a transverse inclination of rather less than 1 in 20. On sending the pulp down the launder without exciting the magnet the solid matter in the pulp followed the lower side of the stream almost entirely. But on exciting the magnet there was an immediate effect which was described as follows in the note made at the time: At the upper end of the launder, before reaching the magnet, the hematite gravitated quickly to the lower side; on reaching the magnet it at once began to move transversely upward across the launder. At the lower end beyond the magnet it swerved downwards at once.

This action is illustrated in plan by Fig. 14. The portion of the launder *b* to *c* 3 ft. long, was over the magnet; the upper and lower portions, *a* to *b* and *c* to *d*, each 1 ft. long, extended beyond the magnet; there was a slight transverse downward slope from *e* to *f* and the launder as a whole sloped from *a* to *d*, as explained above. With the black hematite and the white quartz the movements of the materials were clearly seen. Between *b* and *c* one side or edge of the stream became black with hematite, while the other side was nearly white with the quartz powder. The dotted lines indicate approximately the flow of the hematite as described above. The result justified the experiment, if only because it showed the transverse migration of the concentrate towards one side of the stream without any other agitation or assistance than that provided by the flow of the pulp itself.

Many experiments were made with this apparatus. Although it served its main object, it was too short to enable any reliable tests to be made. With a slow stream the concentrate often formed banks or deposits which tended to imprison streaks of gangue and to deflect the stream, while with a stream quick enough to entirely prevent banking, the transverse movements of the materials were not sufficient in the short distance to give an appreciable concentration. Attempts were made, by passing the products several times down the launder, to improve the concentration, and this was effected, but there was difficulty in collecting the products and no reliable results were obtained.

These tests on the whole supported the view that with a launder of reasonable length and with certain modifications, mostly the outcome of these tests, satisfactory practical results might be looked for.

This magnet was designed for a core induction of about 3,000 B, which was occasionally considerably exceeded with marked improvement in the effect. Quantitative tests were of necessity postponed, but it was realized that for refractory materials like specular hematite a higher induction was desirable, and that in practice it would not increase the cost very much, as it would enable a shorter launder and magnet to be used for a given effect. For magnetite a much lower induction would suffice, certainly under 1,000 B.

The model at the Royal School of Mines was, unfortunately, so made that the side discharge of concentrates referred to above could not be applied. The arrangement was a 5-pole magnet with a balanced 2-phase winding, consisting of two coils only, a useful and simple arrangement, but open to the objection mentioned. The magnet did not comply with the condition previously mentioned as necessary for that purpose that

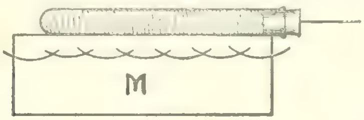

Fig 12.

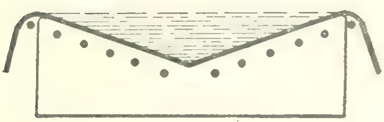

Fig 13.

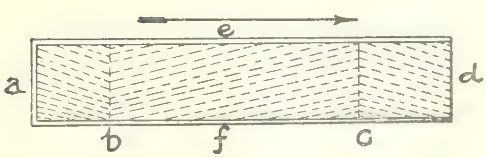

Fig 14.

there should be a winding outside of the side teeth or poles. The side discharge is, however, easily demonstrated otherwise.

The launder experiments confirmed the dish tests in showing considerable differences in the susceptibility of different parts of the same ores to concentration by this method. Most of the value migrates freely and quickly, but there is generally a residue that only moves slowly and unwillingly, and no doubt some that does not respond at all to a field amply powerful for the bulk of the material. This residue requires a stronger excitation.

Probably the cleanest and most complete concentrate would be obtained by graduating the strength of the magnet, either in one passage or successive passages, beginning with a weak magnet, or a low excitation, and ending with a strong one. With a magnet of uniform strength throughout, a certain amount of gangue would be entrained and carried over with the more susceptible part of the concentrate at the upper end. Even with so short a magnet as 3 ft. there was often a very considerable concentration within half that length.

It should be mentioned that the less susceptible residue of specular hematite is usually slightly brown in colour, no doubt due to the crystalline formation having to some extent broken down.

As an example of a dish test, the table herewith is an assay of wet and dry results, for which thanks are due to Mr. F. W. Harbord, of some Dunderland specular hematite ore from which it was stated some magnetite had been previously removed by a permanent magnet. Later experiments showed that if a stronger field had been used the recovery of iron would have been greater.

	80 Mesh Ore as Received.		
	Wet.	Dry.	Magnetite removed.
Iron content of Crude Ore	40·4	40·2	39·4
Phosphorus ,, ,, .	0·101	0·093	—
Iron content of Concentrate	58·9	67·6	67·0
Phosphorus ,, ,, .	0·011	0·005	—
Recovery of Iron . . .	90·4	89·5	89·2
Yield of Concentrate . .	62·1	53·3	52·6
= 1 ton of Concentrate .	1·61	1·875	1·90

In considering possible practical applications, emphasis may be placed on a phenomenon which has been mentioned more than once, the effect of vertical hysteretic repulsion in appearing to modify gravitational conditions. For example, although the specific gravity of specular hematite and of magnetite is nearly twice as great as that of quartz, over a multiphase magnet these iron oxides act as if they were much lighter than quartz. Or take another mineral, tinstone containing wolframite. There is so little difference in the specific gravity of cassiterite and wolframite that ordinary gravitational separation is difficult or impracticable. But a multiphase magnet, in addition to causing a transverse migration of the wolframite makes it in effect much the lighter of the two, and renders gravitational separation easy.

In these experiments, specular hematite was generally used for reasons already sufficiently indicated, but other substances were tried mostly in a tentative way, some with promise of useful results, others with no effect. At an early stage in the experiments a good many tests were made on the separation of wolframite from cassiterite in certain tin ores, as already mentioned. Wolframite behaves very much like specular hematite, in fact, all the qualitative tests made with the latter may equally well be made with the former, the wolframite separating freely from the cassiterite and gangue; but the concentration was not as good as with specular hematite, possibly in part because no amount of crushing will sufficiently separate the components mechanically, and possibly in part because the concentration does not seem to be due to any action on the wolframite, as such, but to iron associated with it. This is illustrated by the following test of the final wolfram product from a uni-directional magnetic separator at a Cornish tin mine. On submitting this product, dry, to a multiphase field of about 2,000 B, it separated into two portions, as follows :—

	%	WO_3	Sn	Fe
Migrated . .	16·8	7·25	11·4	48·15
Did not move .	83·2	71·25	1·75	12·8

It was found by another test that neither pure wolframite crystals nor pure cassiterite made any response to a multiphase field of the above strength.

Some early dish tests were made with chalcopyrite from various sources. For example, a sample described as average Cordoba ore, lightly roasted, gave the following results, wet :—

	%	Cu %
Migrated . . .	48	6·3
Did not move . .	52	1·14

Recovery of Cu 83%.

This result is also probably due to the iron present, in this case oxidized by roasting.

A few negative results may be mentioned, especially as some of them refer to materials that are successfully treated by uni-directional magnetic separators.

Red hematite, the purest found in Cumberland: no response dry; wet, the reddest particles migrated, a small proportion of the whole. Red hematite from Lancashire, no response wet or dry. Monazite sand: ilmenite impurity, no response; ilmenite, no response; franklinite, no response.

Some of the substances which do not respond to weak fields may respond to stronger fields and the use of small air-gaps, but limits are likely to be imposed by hysteresis in the apparatus itself. With uni-directional magnets very intense fields are often used, 20,000 to 25,000 B in the core and not much less in the air-gap. With alternating magnetism such high densities are probably impracticable, although no doubt inductions of 8,000 or 10,000 B could be reached without much difficulty, if it should be worth while. But as these alternating methods with low inductions and open fields can, with certain materials, give effects which cannot be got even with the highest uni-directional fields, there may be a prospect of useful results in that direction.

The author wishes to express his thanks to Messrs. Lancelot and Roland Wilde for valuable laboratory facilities and help, to Professor Truscott and the Royal School of Mines for permission to work in the Bessemer Laboratory, to Professor Mather, F.R.S., for a supply of electrical energy from the adjoining laboratory of the Central Institution, to Mr. Bernard W. Holman, of the Royal School of Mines, for help in the experimental work, and to Sir Thomas K. Rose and Mr. F. W. Harbord for their interest and encouragement.

APPENDIX. — From some experiments shown at the Royal Society Soiree on May 17 which attracted a great deal of attention, the author of the foregoing paper has cleared up some points which were left open when the paper was read, and has extended the area of the research, as will be seen from the following extract from the official programme:

Experiments illustrating, among other effects, the following :—

(1) Repulsion from a multiphase electromagnet of magnetic materials, including finely divided iron, nickel, cobalt, magnetite, and specular hematite.

(2) Steady movement or migration of these materials through or from a multiphase field in a direction opposite to that due to eddy currents. Slow rotation of materials on their own axes under certain conditions.

(3) In 1-phase field, iron, nickel, cobalt, and magnetite act as in a uni-directional field.

(4) Repulsion from the poles of a 1-phase magnet, of finely divided specular hematite (a feebly paramagnetic substance) which forms a ring round and at a distance from each pole — a development of the "equatorial" formation.

(5) The formation in a multiphase field of "planes of force" by iron, nickel, cobalt, and magnetite.

(6) No movement of finely divided aluminium in a multiphase field nor of lead shot.

(7) Water containing any of the above materials driven uphill in a multiphase field—a surface-tension effect.

(8) The possibility of application to the concentration or separation of certain minerals, wet or dry.

The above effects appear to be associated with hysteresis—or rather with hysteresis susceptibility—the movements of repulsion and migration increasing with the frequency up to at least 85 periods per second. At 150 and at 350 periods magnetite and specular hematite exhibit only paramagnetic properties standing erect without motion and oriented to the poles. It is assumed that with these materials hysteresis has ceased or greatly diminished at 150 periods.

The experiments—as was to be expected under the circumstances—were more concerned with physical phenomena than with questions of mineral concentration.

"Planes of Force" were formed by iron, nickel, Sudbury nickel ore, and cobalt, as well as by magnetite. The respective parts played by magnetic attraction and by hysteresis was well illustrated by some experiments with filings of grey cast iron and of Stalloy. The latter, as is well known, is an iron silicon alloy of high permeability and very low hysteresis, whereas the hysteresis of cast iron is very much higher and its permeability comparatively low. The activity of the cast iron in the alternating multiphase field was very much greater than that of Stalloy. It was pointed out that some of the nearly pure forms of iron would probably exhibit little or no movement of repulsion.

The action of the cast iron filings was very instructive. When placed on a wide dish over and close to a long narrow series of poles, they were steadily propelled in a narrow stream over the poles from end to end of the series. But on raising the containing tray several inches above the poles, these filings were scattered widely to right and left of the series of poles, leaving the central or magnetic area quite bare. With specular hematite concentrate, when the tray was close to the poles, the material was piled up on each side of the polar line, which was also left quite bare. The repulsion of magnetic materials from a magnetic field was thus very clearly demonstrated.

The experiments were for the most part with dry crushed materials, and it was noticed that in many cases the photographic dishes containing the materials were covered with glass plates to prevent those materials being ejected from the dishes. Some experiments with wet materials showed that the effect was if anything greater than with dry.

The pseudo-diamagnetic effect of the repulsion of the paramagnetic material, specular hematite, illustrated by Fig. 1 of the paper, was seen in a developed form, the equatorial line taken up by the particles, between the poles of a 1-phase alternate current magnet, being shown to be due to the joining of two complete rings of particles, one round each pole, each ring being the result of the repulsion of the material from the pole. When the alternate poles of a 12-pole magnet were excited by 1-phase (the other phase being un-excited) a series of intersecting rings appeared.

Institution of Mining Engineers.—The general meeting of the Institution of Mining Engineers will be held at Sheffield on June 20, 21, and 22. Among the papers to be read is one by Mr. Eric Davies on the air-cooling plant at St. John del Rey, and arrangements have been made for visits to shafts where the cementation system is being applied.

British Empire Exhibition.—Announcement is made that the British Engineers' Association has been entrusted with the organization of the engineering section of the British Empire Exhibition, which is to be held at Wembley in 1924. Those interested should get into touch with the secretary of the Association, Mr. D. A. Bremner, at 32, Victoria Street, Westminster.

Shipping and Engineering Exhibition. At a meeting of experts held on June 1 it was decided to hold another Shipping, Engineering, and Machinery Exhibition at Olympia in September, 1923. Dr. H. S. Hele-Shaw, President of the Institution of Mechanical Engineers, was elected Chairman of the honorary committee of experts, with Captain H. Riall Sankey as Vice-Chairman. Influential support is being given to the movement, so that the whole forces of the shipping and engineering industries should be represented. The President of the exhibition is Sir Charles A. Parsons, and among the Vice-Presidents are Lord Weir, Sir Archibald Denny, Sir E. H. Tennyson D'Eyncourt, and Engineer Vice-Admiral Sir Geo. G. Goodwin. The general manager is Mr. F. W. Bridges, 4, Vernon Place, W.C. 1.

THE EDUCATION OF A MINING ENGINEER

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Introduction.—There is no well-defined, no well-established standard of mining engineering education in the United States. Curricula vary in length from three to six years; in content, from a fixed curriculum—the same studies without variation for all students—to one in which a fifth of the work is elective; in character of instruction variations are as great, if not greater. The problem is, therefore, in the language of mathematics, one consisting entirely of variables, that is, with no constants, few or no fixed starting points. In other words, the subject of mining engineering education may be approached from many standpoints and observations made from whatever point of view the writer happens to take. Commentators on the subject may be divided into two groups: one typified by the college professor, and the other by the successful practical engineer. Each has his own point of view, and, to his own satisfaction, proves his case, but fails to recognize the point of view or the problem of the other. The engineer in practice is inclined to over-emphasize the importance of the particular phase of mining in which he is engaged. If he is a geologist, he expects the young graduate to be well versed in geology and to reason clearly from effect back to cause; otherwise he is apt to condemn the man and the school from which he comes. Also, the mine manager expects the young graduate to be familiar with mining methods and to have had training in " human engineering ", the handling of men. Unless the young graduate shows a knowledge and skill in these particular subjects, the mine manager condemns him and his school. In other words, each one expects to get from a school of mines a finished product, adapted to his own particular needs. Rarely does the practising engineer appreciate the actual condition of the young graduate. In reality, all he should expect is the partly developed material from which a mining engineer can be produced: an embryonic engineer with a good grounding in fundamentals but with only a general fund of details and special applications. The college professor, on the other hand, receives the absolutely raw material, in the substance of a freshman class, generally an unlikely, unpropitious, and heterogenous aggregation. This group he is expected to sift, sort, train, develop, inspire, and from it evolve a " finished product " in four years. No one, in his right mind, who has had intimate acquaintance with a freshmen class would hope to accomplish such an impossibility. The most he can do is to eliminate the unfit, inspire the mediocre, and give the best an opportunity to expand and develop into potential material from which a mining engineer may subsequently develop.

Fallacies.—(*a*) After an experience of more than thirty years, I am inclined to think that the most glaring fallacy to-day is the generally unrecognized but actual assumption that a technical school is established merely to carry out a prescribed course of study without due consideration for the material affected, that is, the students themselves. The true ideal of a school of mines should be to train each individual student so that he may make the most of himself, as a man, as a citizen, and as a mining engineer. The personal instruction he receives and the course of study he pursues, should be a means to that end and not an end in itself. Too often the operation of a course of study itself is regarded by the faculty as the end to be sought rather than the development of the individual. Whereas, the individual is of vastly more consequence than any theoretical course of study whatever.

(*b*) The average student does not exist in flesh and blood. There are groups, however, that have certain common characteristics, that is, the indifferent, the lazy, the brilliant, the ambitious, the talented, and the plodder, but there are no two individuals exactly alike in all particulars. This fallacy of the " average student " is the cause of much inefficiency in teaching, because it erects a false goal at which the instructor aims. Instead of trying to reach the average student the teacher should endeavour to reach the individual. In matters of conduct and discipline, the fallacy of the " average student " is still more pronounced, because the offender should always be viewed as " some mother's boy," and judged as such and not as a mere impersonal unit guilty of some transgression.

(*c*) The Faculty of a school is composed of a group of individuals, each one a specialist.

As an authority in his own subject his word cannot properly be questioned. However, a Board of Trustees selects him and others, specialists like himself, in some one subject, to form a Faculty. Then this Faculty, as a whole, is expected, by some legerdemain, to become expert in management, organization, policies, course of study, finance, and school ideals, all of which subjects are probably foreign to the training, education, and experience of each individual. To be explicit, consider a distinguished metallurgist, an investigator, a prince of the profession; call him to the Faculty of a school of mines, expect him, without experience in teaching, without a study of educational practice, ideals, or tendencies, with a slight knowledge of industrial needs, expect him to pass unerringly upon the great moral, ethical, educational, pedagogical, practical, and technical questions covering the ideals of a great school. One is asking for the virtually impossible. Multiply his case by the number in the whole Faculty and the usual Faculty results. To avoid the errors resulting from this fallacy there is needed at the head of higher technical schools men who have made a careful study of general educational methods, the tendencies of the time, the state and needs of the industry, finance, management, administration, human nature, and who are themselves broadly educated, sympathetically inclined towards all subjects of study, and have well-balanced judgment and vision; in other words, leaders of men, specialists above specialists. Naturally, such men are rarely found.

(*d*) Another fallacy is the generalization from a particular case. An individual student, weak and indifferent, by means of fortuitious circumstances may occasionally barely pass with the lowest possible grades. He goes out into the engineering world and fails. The school as a whole is blamed and all its graduates are held to be of his calibre. The opposite conclusion is drawn from a graduate of innate ability, above the average. Logically, both conclusions are fallacious. The acid test of any school of mines is, of course, its graduates—not one but many—their character, their training, and their ability to think. The same fallacy as this appears within the college confines. A few students indulge in unseemly orgies; Dame Rumour concludes that all students do so. A few students " crib " or " cheat "; campus gossip reports that all students are dishonest. It is only fair and just that all ascertainable facts be secured before judgment is passed, no matter what subject is under consideration. Such justice is, unfortunately, but rarely accorded.

(*e*) Still another fallacy is to regard the Faculty as of one uniform type and the student body as of another uniform type. Too often writers refer to a student body as if each student were exactly like every other student. This is by no means true. As individuals they vary widely in moral stamina, in preliminary training, in mental ability, in energy, in power of concentration, in clear thinking, in previous home training and environment, and in ambition. It is also assumed that a Faculty consists only of high-minded men, devoted to their work, self-sacrificing, patient, and long-suffering. Although this is generally true, yet some black sheep do slip in. On the whole, if we exclude the extremes of the very rich and the very poor, the genius and the dullard, both Faculty and students represent fairly well a cross section of average society with all the varied elements represented. Both should be analysed as such.

(*f*) Another fallacy is that a Faculty can prescribe a single course of study that is best, without any exceptions whatever, for all students and will best equip each and every young man for his life's work. This, on the face of it, seems reasonable, and is frequently accepted as final. Why not? The members of the Faculty are older, more experienced. They know better than the undergraduate what he should study. The case seems simple; can anything more be said? Certainly. Analyse the situation. The entering freshman class, let us say, numbers a hundred men. All that the Faculty knows about these men at the start is contained in a brief statistical record, on a single sheet of paper, with perhaps a few formal examination papers. Nothing truly definitely is known of each man's character, ambitions, home environment, social connexion, or real mental ability. The student is then put through the regular course of study. With rare exceptions professor and student seldom meet outside of the lecture room. Few, indeed, are the cases, especially in the larger institutions, where professor and student get close together and become well acquainted. The single course is pursued throughout the four years with no attention whatever paid to the natural talents, the taste, or the aptitude of the individual student. He must take the subjects laid down by the Faculty; whether the study is the fad of an over-zealous professor or one of fundamental importance makes no difference. The student has no choice. He must take it or get out. It may be said in rejoinder that many successful engineers have resulted from such training. Admittedly so. It has still to be shown that they were successful because of the rigid course and not in spite of it. I have had experience with many teachers and students and have yet to meet a Faculty that, as a whole, possesses such unfailing good judgment, prophetic vision, deep insight into human character, and omniscence that it can prescribe unfailingly every hour of a student's time for four years and prepare him perfectly for his life's work. There are too many shifting, variable, and uncertain elements involved in this problem of human nature to make its correct solution possible in all cases. Yet some Faculties delude themselves into thinking that they can and believe that they are doing it successfully.

PRESENT-DAY CURRICULA.—A most thorough investigation of the present curricula of mining schools in the United States was made recently by a committee of the Mining and Metallurgical Society of America and published as *Bulletin* 150 of the Society. The committee consisted of three eminent engineers, A. H. Rogers, L. C. Graton, and H. A. Guess. Their report is illuminating in that it shows an almost unbelievable variation in both the theory and practice of what should really be embodied in a mining engineering curriculum. The curricula of twenty-four mining schools were examined, representing all classes of schools, that is, departments of state-supported and private universities, endowed private detached, and state-supported detached schools. The following table gives the results of their investigations of the maximum, the minimum, and the average time, on a percentage basis, given to the various subjects taught:—

	Maximum	*Minimum*	*Average*
Mathematics . . .	16·8	6·1	10·5
Physics and Mechanics	13·2	4·0	9·2
Mechanical Drawing .	8·6	2·8	[illegible]
Chemistry . . .	15·7	7·3	11·0
Geology and Mineralogy	17·7	4·3	[illegible]
Surveying and Mapping	7·4	1·0	[illegible]
Civil, Mechanical, and Electrical Engineering	17·9	7·1	[illegible]
Mining Engineering .	19·1	4·4	[illegible]
Metallurgy and Ore-Dressing	18·4	4·4	10·9

The astounding revelation from this table is the utter absence of unity, coherence, or fixed ideals. The wide variation between the maximum and minimum time required in the same subject in different schools suggests either a lack of appreciation, a fanatical zeal, or a wide difference of honest opinion. Why should one school of mines require less than 5% of a student's time in geology and a neighbouring school require more than 17%. Also, why is one group of mining engineering students so brilliant that with only 6·1% of their time given to mathematics they can succeed, whereas another group, presumably similar in all respects, must devote 16·8% of their time to the same subject? Finally, how can students of a school of mines that makes any pretence whatever to a high technical mining standard succeed with less than 9% of their time devoted to mining, metallurgy, and ore-dressing? These pertinent questions have not as yet received a satisfactory answer. In only nine schools is thesis work required for graduation, even though the ability to meet and solve new problems is a prime requisite for a mining engineer. Of the twenty-four mining schools examined, fifteen have curricula in which the studies are definitely prescribed throughout for all students; eight allow electives in amount from 1·3 to 9% of the time of the curriculum. One school, the Colorado School of Mines, allows 20·4% of electives. It may be a significant fact to notice that this school has the largest attendance of any mining school in the United States. Over-zealous advisers urge the inclusion, in the mining school curriculum, of modern languages, economics, literature, history, and a long list of cultural studies. Calculation shows that to include all the varied subjects thus designated into one single required curriculum would require an extension of the four-year course to one covering a quarter of a century. Such self-appointed critics never have come into personal contact with the raw, unbaked material that presents itself each year to the mining schools for education and training. A very large number of students elect a technical course in general, or a mining course in particular, because of their natural aversion to language and literary studies, their ineptitude for strictly cultural subjects, and their natural fondness for scientific studies with their direct application. They will do their plane-surveying on Saturdays, or holidays, without being urged and with keen delight. They will work even all night in the assay laboratory. It is exceedingly questionable how much cultural study should be required in our ordinary four-year curriculum in schools supported by general taxation. A serious attempt to require as much literary and cultural study from our body of mining students, as zealous advocates advise would require an intellectual force pump in every class room. It is eminently proper for a university, privately endowed, to organize a post-graduate school and to require two years of previous general cultural training. Such a plan meets the needs of a small class of selected students and will raise the general standard, but would be fatal to the success of the standard four-year curriculum in our numerous publicly supported technical or mining schools.

ANALYSIS OF SUBJECTS.—Few writers take the trouble to analyse the varied qualities a mining engineer should possess beyond one grouping of technical and another of cultural elements. Such a division is by no means complete. Every young man inherits certain mental, physical, and moral traits. These may be modified or intensified by his college training, his environment, and precept from his elders. However, they are a part of his general make-up and must be considered in any scheme of training. Politically, we all may be born equal, but there the parallelism ends. One man has a large physical frame, has initiative, resourcefulness, and natural leadership of men. Why should he, beyond receiving a basal training in drawing, be required to spend long hours over a drawing board when he never can make a skilled draughtsman of himself ? His success lies in a widely different field. He is destined to be the superintendent or the manager. Another man is the careful methodical student, the laboratory investigator, the strictly indoor scientific man to solve intricate chemical or metallurgical problems. Beyond the fundamentals of geology, why should he, for example, be required to go deeply into the subject of the genesis of ore deposits ? He is destined to be a research metallurgist or chemist. Why spoil a good chemist to make an indifferent geologist, a weak executive, or a poor draughtsman ? There is also a group of personal characteristics desirable for any man to have : personal honour, integrity, reliability, and similar traits. These traits are acquired more by example and by personal contact with the better class of men than by teaching. The third group of subjects, the technical and formal, form the back-bone of any technical course. In the arrangement of these, a single-track curriculum assumes too much conceit and dogmatism on the part of the Faculty, too little regard for the native talents of the individuals, and too much assumption of what each young man's future is to be. Furthermore, too great detail in the subjects taught may also be fatal. The safe middle course is to emphasize and insist upon a thorough grasp of the fundamentals of physics, chemistry, and mathematics, including descriptive geometry, as a foundation for all good engineering practice. If these subjects are thoroughly mastered, variation in the later subjects becomes of minor importance. The most essential element of all, overshadowing every other phase of the subject, is to teach a young man to observe closely, and to think clearly, logically, and accurately. If this is done, a young man, irrespective of whether he has studied under Professor A or Professor B, regardless of whether his time has been spent in the assay laboratory, in the mineralogical collection, in the drawing room, or in the chemical laboratory, has received an education, because the essential difference between the uneducated and the educated is the ability to think.

THINKING.—Inductive reasoning, that which advances our knowledge, consists of four steps : (1) Careful and correct observation of facts ; (2) the formation of a tentative generalization or working hypothesis to explain the facts ; (3) prediction of the unknown, under the assumption that the generalization is correct ; (4) verification. This complete cycle can, of course, be exercised only by the original scientific investigator, but the spirit of it is adopted by every effective teacher in training a student in accurate observation and clear thinking. For pure exposition, no better form can be used than the method of the old Aristotelian logic, namely, from the general to the particular, from the indefinite to the concrete, from the whole to the parts. The human mind naturally functions in this way. Read again Goldsmith's " Deserted Village." Note his first verse—

Sweet Auburn ! loveliest village of the plain,

which is a perfectly general statement followed by details in the description of the village. Then minor wholes are treated in the same way as—

There, where a few torn shrubs the place disclose,
The village preacher's modest mansion rose,

and again—

> Beside yon straggling fence that skirts the way,
> With blossom'd furze unprofitably gay,
> There, in his noisy mansion, skilled to rule,
> The village master taught his little school.

A logical analysis shows that Goldsmith, though by no means a logician or a teacher himself, hit upon a perfect construction for "The Deserted Village," the construction which moves from the whole to the particular parts. Inasmuch as this procedure is in harmony with the orderly working of the human mind, the reader easily receives a perfect mental picture. The same procedure is used effectively by descriptive writers like Washington Irving or Stevenson. Aside from pure literature the same principle applies in editorial work and newspaper "stories." The editor demands that the first sentence shall embody the whole story. Headlines and captions are good illustrations of this idea. A well constructed paragraph, on any subject, requires a topic sentence at the beginning, followed by details, and a concluding sentence that closes the subject. A well-constructed sermon, a carefully prepared lecture, or an effective argument, is necessarily constructed on this plan. A good teacher arranges his course as a whole, and each division or lecture on this plan, because it follows the direct avenue to the human mind, is the line of least resistance which results in effective teaching. Aside from personally effective characteristics and a thorough knowledge of his subject, a teacher should have a good understanding of psychology in its pedagogical aspect. Not that he should teach psychology, but that all of his work with students should be based upon correct psychological principles. Specifically, his lectures, his demonstrations, his explanations, should always be based upon the logical plan of going from the general to the particular. Many a teacher has failed because he did not realize the transscendent importance of this logical principle.

TYPES OF STUDENTS.—The most numerous of any type of student that has come under my observation is the strong, sturdy, aggressive, independent young American, ready on call to lead a football team to victory, preside at a class meeting, answer the call for helpers on occasion of a great national calamity, enlist for the war, gather a group of workmen, go into the hills, establish a camp and develop a mining prospect, or join an expedition to seek for oil in the Arctic regions or the wilds of Africa. These young Americans are the bone and sinew of the next generation. Those of us who enjoy the delight of associating with such young men, as guide, leader, or elder brother, do not get enthusiastic over the well-meaning but misguided advice of outsiders that they would become greater men if we forced them to appreciate Browning. No! Success in developing the resources of nature, in advancing the state of civilization, and in making this a better world to live in, has a dignity and character all its own and should not be confused with the culture to be obtained by following a purely literary career. Another type of student has mental characteristics strongly developed. He has the strictly scientific point of view. His habitat is the laboratory. He is a thinker and essentially an indoor man. His success may not be spectacular, he may be known only in technical circles, but his work is eminently efficient. He should be given the opportunity to train himself to a method of strict scientific thought, accurate observation, and logical reasoning. Without him, mining science could not advance. A third type shows very early a distinct businesslike character. His studies are all virtually interesting to him if they bear upon life's activities. He is a student of human nature; he studies men as well as things. He is constantly finding ways in which to earn a little money. He is an all-round individual. If he has a fair opportunity, after leaving college, he soon gets into the business side of mining and, later on, becomes an executive. A fourth type is the mentally slow, the man who acquires with difficulty, but is thorough and substantial and has good common sense. He is popularly called the "plodder." There is a niche for him in the mining industry and occasionally he comes to the fore, possibly to the surprise of the unthinking. A fifth type consists of a motley group of the stupid, the misfits, the lazy, and the generally unworthy, who fall by the wayside and are as soon forgotten. A practical test of a mining school is the percentage of good material it can produce from the raw material that comes to it annually as freshmen.

TEACHING VERSUS LECTURING.—Many writers on education fail to recognize the difference between mere lecturing and actual, Simon-pure teaching. Mere lecturing, the presentation of facts, even if done in logical order, is not teaching. The youth eats, sleeps, exercises, and develops day by day his physical body. In a parallel way his spiritual, moral, and mental being is slowly developed. For the sake of simplicity, consider only his mental development. This development comes slowly, hour by hour, day by day. The real purpose of the teacher is to establish such a regular plan of work as to aid this development. The substance and not the shadow must be presented. A menu card will not take the place of a substantial meal. The baby crying for milk is not appeased by a milk ticket. As proper food and exercise vary with the physical needs of of the individual, so do the mental food and exercise vary. The individual seeking education is faced with a problem of work, work on his own part. He cannot sit idly back, view motion pictures, listen to lectures, fill a notebook with facts, and become educated. He must assimilate the material put before him, make it a part of his mental warp and woof, just as his system assimilates the food he puts into it. Such mental assimilation results only from careful attention, close application, revision, review, concentration, and thought. No subject can be thoroughly assimilated until it has been gone over again and again ; till the beginning is viewed in the light of the end ; the end in the light of the beginning ; and the middle viewed from both ends. The crucial test of mastery of a subject consists of three parts : the ability to make a logical outline of it, correct in all details ; to condense it all into a few words ; and to expand on any detail. Mere presentation of facts by lecturing does not accomplish this, but real teaching does. Every good preacher is part teacher ; every good teacher is part preacher. The task of each is not an easy one. The work is wearying and exhausting ; that is, to speak figuratively, if the teacher believes that a student should drink from a running brook rather than from a stagnant pool. However, the greatest delight for a teacher is to be associated with a group of ambitious students, seeking to make the most of themselves, and his greatest compensation is to see them succeed in their life work, whatever it may be.

Character Study.—Mere acquisition of knowledge is not sufficient. It does not develop power. The encyclopedic mind is not for the mining engineer. Ordinary forms of instruction are static ; the training of a mining engineer should be dynamic. He should not be told that he is merely in training for life but that he is fighting life's real battle circumscribed, planned, and limited perhaps, yet in embryo living his real life ; that he is a generator and not a storage battery ; that wisdom is better than knowledge ; that knowledge alone is not the key to success. Judgment of a student should not be based on a mere test of his knowledge, but should consider his potentialities. Study should be made of his character, initiative, executive, ability, morale, manners, technical ability, command of English, personality, heredity, ambitions, and prospects. That is, he should be judged as a full man and not as a mere recording machine or phonograph.

Breadth of Mining.—Of all the branches of engineering, mining has the broadest field, requires the widest range of knowledge, and develops the greatest number of human potentialities. The mining engineer may be called upon for ability in drawing, design, geology, chemistry, mechanical, electrical, or civil engineering, besides a knowledge of law, economics, business, and administration. Not that he needs to be an expert in these branches, but at some time in his career he may need more than a mere formal acquaintance with them. In fact, almost any kind of knowledge, or skill even to the homely art of camp cooking, may be a convenience or even a necessity. For this reason, the glaring fallacy of trying to prescribe unfailingly the exact subject, period, and content of every hour of a man's time for four years becomes apparent. At best, the curriculum can be only a resultant of many conflicting forces, with a form and content that will represent opportunities for the individual.

An Opportunity.—It is a mistake for any body of men, even a mining school Faculty, to assume that it can judge unerringly of each student's latent talents, his ambitions, his vitality, his vigour, his mentality, his occupation after graduation, or in brief his whole future career. In the rarest of rare cases a young man knows exactly what he will do. To outline a course of study for him is simplicity itself. The majority of students are, after graduation, victims of circumstances. For any group of men whatever, even college professionals, to claim unfailing judgment in the case of each young graduate is to claim a power to see into the future claimed in ancient times only by the soothsayers and to-day only by spiritualists, fortune-tellers, and their class. The present-day mining school should be not a mere group of buildings where distinguished scholars teach, but a " great opportunity ", where young men may go and find the environment wherein each one can develop his own powers, under the best advice he can obtain from any source whatever, so as to make his own individual life work a success. To quote General Walker's classic phrase a mining school should be a "place where men may work and not where boys may play."

A TWENTIETH CENTURY CURRICULUM.—Destructive criticism or mere logical analysis that results in no suggestion for improvement is useless and worthy only of the pessimist. The curriculum most likely to give the maximum of good results in the education of a mining engineer is one founded on a basis of a thorough, fundamental knowledge of physics, chemistry, and mathematics. A rigid course in descriptive geometry should be demanded because of its training of the imagination and the art of thinking clearly in three dimensions. These fundamentals should cover the first half, the freshman and sophomore years, of the regular four-year course. To these fundamentals should be added mechanical drawing, lettering, surveying, general geology, crystallography, and mineralogy. These courses, absolutely fundamental for any branch of mining engineering, should be required of all students. They form an irreducible minimum. Needless to say these fundamentals should be taught thoroughly not by young inexperienced members of a Faculty, but by the best teachers obtainable. During the second half of the curriculum, a student should be allowed to major in that branch which his talents, his innate fondness, and his judgment dictate to be the one he is best fitted to pursue; for example, practical mining, metallurgy, geology, oil, or chemistry. After choosing a major, a few basal courses should be prescribed. The time remaining should be given to a judicious selection of courses in the other curricula. The degree should be conferred when a man has completed the required work of the freshman and sophomore years, the prescribed work in his chosen group, and sufficient elective hours to meet the number required for a degree.

It may be granted that such a curriculum is based upon the elective principle. That is true, but the fundamental subjects are by no means neglected, nor is too early specialization advocated. Besides, there is the utmost latitude for a student to develop his own latent ability without wasting his time; the brilliant student is not held back by the mediocre or lazy member of his class. The criticism often has come to me seriously from parents, engineers, and thoughtful students, that the pet theories of individual members of a Faculty should not be inflicted upon students regardless of the student's innate capabilities. The elective principle first comes into force when a young man selects a mining rather than a law course. After he enters, the question of what he will select is ever before him. He is not one sheep to follow implicitly the sound of the bell. He is a rational human being, expected to carve out his own career. Naturally the value of various subjects are discussed freely among the students, with members of the Faculty, with engineers, or with distinguished men who visit the school. The choice of an individual student results from a variety of influences, and usually I have found it to be wise. It may be urged that students will elect "soft" courses. In a well-organized mining school there should be no "soft" courses. Should a member of the Faculty stoop to the low trick of trying to gain popularity and prestige by making his course easy he is out of place in a self-respecting Faculty. The right-minded student, intent on getting the best possible preparation for his life's work, does not want "snap" courses. He prefers strong, thorough, comprehensive courses, well taught, with a high degree of attainment demanded. It is a pleasure to record, from my personal experience, that the well-intentioned young American student wants high-grade teaching, desires only a fair chance, and craves an opportunity to develop himself; his criticism of a poor teacher is merciless. To-day the mining school that offers high-grade instruction, "stiff" courses, and thorough teaching, demands effective work from the students, gives the best opportunity for self-development, and presents high ideals is the school sought by the best type of young Americans.

CONCLUSION.—The Great War caused destruction of property to an extent never before witnessed in the history of the world. This property must all be rebuilt or renewed. The next decade will be distinctly an engineering age. The world needs regeneration, rebuilding. There never has been such a demand for engineers as will develop in the present decade. The mining school has its work to do. If this is done well, the school must have certain well-defined characteristics:

(*a*) A school of mines must be democratic in tone, with a fair and individual chance given to each and every man.

(*b*) It must be essentially an "opportunity" where the individual may develop, to the highest degree, his own innate capabilities.

(*c*) It should be a place "where men may work and not where boys may play."

(*d*) It should exert the utmost effort by example and environment to develop the morale, the character, and the finer elements of manhood.

(*e*) It should limit the required subjects of study to the fundamentals and a wide latitude of electives allowed to permit individual delevopment.

In fine, the function of a school of mines should be to develop embryonic engineers, possessed of the fundamentals, good citizens, and all-round substantial members of society.

The recent international conference on the limitations of armaments was influenced by the high ideals of Secretary of State Hughes and President Harding. It was an epoch-making event in the history of civilization. It gave an enduring phrase to all human endeavour whether in the field of politics, law, medicine, business, manual labour, or education, a phrase that may well be remembered by every one engaged in any occupation and especially with those who are guiding the young to a useful life and have the responsibility of moulding the character and habits of the next generation. President Harding's fruitful phrase, tersely put, was that we should all be "more concerned with living to the fulfilment of God's high intent."

BOOK REVIEWS

The Economics of Petroleum. By JOSEPH E. POGUE. Cloth, octavo, 360 pages, illustrated. Price 33s. New York: John Wiley & Sons. London: Chapman & Hall, Ltd.

This book is by far the most interesting and valuable publication dealing with the petroleum industry that has come across the Atlantic for some time. This can be said without any disparagement of many useful books recently reviewed in the MAGAZINE. Dealing as it does with the subject from the economic side and not from the technical, it nevertheless deserves the earnest consideration of all concerned in the industry, both technical and business men.

The scope of the work is primarily limited to the American petroleum industry, and, much as one would like to see the whole world similarly dealt with, it is obvious that such could not be done, at any rate for the war and post-war periods which form the most valuable subject-matter of this book. The only previous work that can be recalled is the fifth volume of *Das Erdöl*, in which the material is mainly pre-war, and which in spite of wealth of information can scarcely be held up as a model of clarity of exposition. It is precisely in regard to these latter points that the present work deserves special commendation, all statistical information whether in tabular or graphical form being well thought out.

Although the bulk of the work is occupied with an analysis of the principal factors bearing on the demand and on the price of the various petroleum products and the inter-relationship of these two, much useful information in a condensed form is given on that all-important subject of resources to which Chapter II is devoted, while equally the question of substitutes for oil as derived from coal and shale is ventilated. We agree with the author in his interpretation of supply (p. 21) that it "may be expected to spread over a greater period of time and a wider range of essential service than would appear from an unqualified consideration of the figures alone." In fact, without in any way wishing to detract from the valuable estimates of unmined supply which have of late years been prepared in the United States, where the conditions of occurrence of petroleum lend themselves best to such calculations, most oilmen in other parts of the world would hesitate to limit the future supplies quite so drastically as composite decline curves tend to show. We still look forward to more scientific methods both as regards exploitation and extraction, while recognizing the valuable influence brought to bear on the careful study of such data by the requirements of the United States Treasury in regard to the taxation of oil properties.

Another point of great importance which is well brought out is the rapidity with which consumption has overtaken and passed production in the United States since 1915. Thus Fig. 21 on p. 60, which gives the trend of the crude petroleum situation in the United States from 1917–21, deserves special note. It is worthy of note too that in regard to prices of products those of gasoline and kerosene do not fall to a marked degree under the normal operation of supply and demand (p. 105) as do those of lubricating and fuel oils. It is the interesting analysis of the fluctuating importance of these various products in recent years, more particularly influenced by the "automatic demand" which constitutes the most valuable part of the work. The extent to which the motor lorry and tractor have become an integral part of the agricultural life in the United States may be gauged by reference to Figs. 132 and 133, and it is especially interesting to note that the peak of the kerosene demand due to seasonal factors has been lost in the levelling effect of such demands. On the other hand, the gasoline peak load has become more and more accentuated.

Finally, all having the interests of both the industrial future and of the oil industry at heart will heartily endorse the author's all-round plea (Chapter XXVII) for efficiency. Petroleum plays such a vital role in the world's life that all departments, prospecting, production, refining, and utilization must be carried on only with strictest economy of the right kind. No product should be used for any purpose other than the highest for which it is suited. T. G. MADGWICK.

A Manual of Determinative Mineralogy. By J. VOLNEY LEWIS. Third edition, revised and enlarged. Cloth, octavo, illustrated, 298 pages. Price 16s. 6d. New York: John Wiley & Sons; London: Chapman & Hall, Ltd.

In this edition the blowpipe tables have been thoroughly revised and a new classification of minerals based on physical characters has been added. This classification differs from many others in being based on such characters as streak, cleavage, colour, hardness, and density. Lustre is entirely omitted as a basis, which is an advantage, as the lustre of one mineral may vary within wide limits.

The book opens with a short chapter on the physical properties of minerals, occupying eleven pages only, which is followed by the physical classification of the minerals. Then comes a careful description of the apparatus and methods at blowpipe analysis, with tables of the chief reactions. This is followed by a list of the characteristic reactions of each element, and last comes a series of determinative tables based on the blowpipe reactions of the minerals. There are in addition tables of minerals classified according to crystal form, lustre, and hardness, and a glossary of geological and mineralogical terms.

The physical tables are well planned, and the student can depend on them for the determination of minerals. No microscopic characters are given, which, considering the extent to which the microscope is now used, seems to limit the use of the book. The blowpipe tables seem to be complete and accurate, but one or two of the definitions in the glossary need revision; for example, the definition of the term "drusy" does not convey a true idea of the structure. Some rock names are defined, such as granite, peridotite, etc.; others, such as gabbro and diorite, are omitted.

E. H. DAVISON.

Handbook for Field Geologists. By C. W. HAYES. Third edition, revised and rearranged by Sidney Paige. Cloth, octavo, illustrated, 166 pages. Price 13s. 6d. New York: John Wiley & Sons; London: Chapman & Hall, Ltd.

Hayes' Field Geology has been well known to geologists since its first publication in 1909, and there is no doubt of the welcome which awaits a third edition. The revision and rearrangement have been carried out by Sidney Paige, of the United States Geological Survey, and have materially improved the book. New matter includes a brief mineralogy in an appendix by E. S. Larsen, which is followed by a list of official geological surveys of North America. The inclusion here of the chief European and Colonial surveys would be of advantage to the British student.

The description of work with the plane-table has been revised, as also have some of the schedules, and new calculation tables in stratigraphy have been added. One would like to see the inclusion of a determinative table of rocks based on hand specimen characters.

For the benefit of those not familiar with previous editions, it may be said that the book is full of matter of practical interest to the field geologist. Such subjects as preparation for field work, field outfit, field observations, horizontal, angular, and vertical measurements, field map and profile notes, land classification, mine surveys, and the collection of specimens for various purposes are dealt with in detail, yet the author does not lose sight of the fact that he is writing a field handbook and not a work of reference.

In Part II a number of schedules are given indicating the essential features to be noted in various special investigations. The titles include land forms, igneous, sedimentary, and metamorphic rocks, structural geology, glacial deposits, metalliferous deposits, coal, stone, road metal, cement material, clay, sand, and gravel.

The revision has been carried out so as to add to the value of a book which has always been of great use both to the embryo field geologist and to the experienced worker. The characteristic of the book is that it is content to be a field handbook, and does not attempt to be a textbook also.

E. H. DAVISON.

Surveying for Settlers. By WILLIAM CROSLEY. Cloth, 16mo., 159 pages, illustrated. Price 7s. 6d. net. London: Crosby Lockwood & Son.

This book is divided into six chapters, to which are added an appendix, and some notes on irrigation in Rhodesia. The subject matter includes: Measurement of areas by tape and chain, booking, plotting of plans, computation of areas, angular measurement, use of prismatic compass and plain miner's dial, elementary trigonometry and co-ordinates, levelling with dumpy level and clinometer, use of road tracer, height by barometer, measurement, conveyance, and storage of water, wind-driven pumps, water wheels, road-making, and measurement of solids.

As the title indicates, the book is directed to the needs of the farmer, planter, rancher, or prospector, who in the development of his holding often requires to know its physical characteristics and to construct improvements of a simple engineering type, with the view of showing him how any man of average intelligence possessing some knowledge of arithmetic can deal with matters necessitating simple surveying without having to consult textbooks, which he probably would not be able to follow, or to call in professional assistance, which he might well dispense with. The treatise does not invite much in the way of criticism. Since the traversing with the instruments recommended consists of loose-needle work, it may appear unnecessary to deal with the question of calculating and plotting by co-ordinates. The settler with no or little knowledge of trigonometry may find this section of the book difficult to absorb. The lucid manner in which the author explains the nature of a trigonometrical function and the derivation and use of co-ordinates should, however, make things clear. Although the theodolite is of too fine a construction for the requirements of the class of work intended, mention might have been made of the plane table and Abney level, both of which are useful instruments in work of this nature. The illustrations are helpful; and altogether the book, which is written by a mining engineer, lately deceased, who had much pioneering experience, is undoubtedly a useful one for the settler to have by him.

ALEX. RICHARDSON.

LETTER TO THE EDITOR

Jamaica

The Editor:

SIR—The article on Jamaica in the April issue, based upon the Geological Survey report of 1869, states that little or no mining has been done since that date, the residents not being interested in such operations. As a matter of record, these statements may be disputed. Many of the land-owners and planters are keenly desirous of finding a mine on their property, and many small showings have been opened up by them. The same applies even to many of the negro small-holders.

Reference is made to the galena vein at Thomasfield. This was first worked by Jamaicans in 1844, and later by an English company in 1859 to 1862. This latter did work upon many prospects throughout the island without success. In 1912 the Thomasfield prospect was taken up by a London syndicate, which mined, sorted, and sold 22 tons of mixed sulphide ore, averaging 10% lead, 13% zinc, and $1\frac{1}{2}$ oz. each of gold and silver. In the spring of 1914 I inspected the property and reopened the caved workings of the early operators. No ore was in sight, but the evidence showed a feeble mineralization in the form of stringers and bunches at a zone of cross-faulting in metamorphosed sedimentaries. Further development would necessitate sinking at the edge of the river, with very heavy pumping. Shortly after my visit the war broke out, and nothing further has been done.

The first English company prospected some small copper showings on the same property. The old drifts were cleared out for my inspection, but nothing warranting further work was to be seen.

The fact is well known that a good deal of scattered and weak mineralization exists in the island, but no concentration sufficient to warrant mining has yet been discovered.

The analogy drawn by the writer as existing between Jamaica and Cuba, the only difference being as to size, cannot be accepted. In the latter island large ore-bodies existed, at, or near, the surface; no such are known in Jamaica. Also the geological conditions are dissimilar in several important respects.

A. H. BROMLY.

London, *May* 17.

NEWS LETTERS

SOUTH AFRICA

May 9.

RAND WAGES.—The Chamber of Mines has issued the schedule of wages to be adopted on the Rand mines. The figures should be of interest to mine operators all the world over, for the living conditions on the Rand have been brought more and more into line with those of advanced industrial communities in other countries. The list gives minimum rates only, upon which advances are to be made by managers according to efficiency and service. There is an additional 2s. 3d. per shift cost of living allowance, which will remain in force till June 30. The chief minimum rates are :—

Winding Engine Drivers—
- Surface, 2s. 6d. and 2s. 9d. per hour.
- Underground, 2s. 8½d. and 2s. 11½d. per hour.

Mechanics—
- Surface, 2s. 6d. per hour.
- Underground, 22s. 6d. per shift.

Underground Employees (General)—
- 6 months' experience, 12s. 6d. per shift.
- 15 months' experience, 15s. per shift.

Regulations covering underground men of experience employed (1) as machine-men, hammer-men, and timber-men, and (2) plate-layers, pipe-men, truck-repairers, pump-chargemen, masons, and ropemen, are more complicated. Broadly, no man really experienced in the job he is performing in group (1) or (2) will receive less than 20s. per shift.

Apprentices receive a rate increasing from 2s. per day (first year) to 8s. 6d. per day (fifth year).

Accusations are made in some quarters that since the strike employers and managers are unduly exercising the powers of victory and attempting to humiliate returned strikers by giving minimum rates in return for the highest efficiency. Such suggestions are to be expected. Broadly, however, the attitude of managers is just and resolute. Agitators are being kept out and good men encouraged, even though these latter may feel impatient under the minimum wage that will only be increased upon receiving more than the standard of minimum efficiency current in the last few years. No mine manager to-day, in his need for lower working costs, can afford to humiliate or dissatisfy his efficient miner or mechanic, merely to continue teaching him a lesson. Zeal and efficiency are too scarce. But mine managers may take considerable time to put their houses in order.

HAND-HAMMER-DRILLS IN STOPING.—The development of hand-hammer-drill practice in Rand stoping, where minimum widths are so important and supplies of efficient hammer-boys inadequate, has been slow, but sure. The retarding factor has always been the question of suitable rig or support to carry the weight and take the concussion of the machine, which is too severe even for the nerveless Kafir. There are numerous devices for this purpose; in fact, they have been too numerous. Each mine has favoured its own, and in spite of reports and exhibitions, a standard practice has not been evolved. The Village Deep now stands on a hand-hammer-drill basis for all machine stoping. The results of their experience with cradles or rigs would be appreciated elsewhere along the Reef.

CEMENTATION PROCESS.—The Francois cementation process, which has many friends on the Rand, and will not fail to progress for lack of imagination among prospective users, was applied at the New Kleinfontein mine last year to the work of supporting the hanging wall. A year has passed without further trouble with the hanging treated.

COST OF CIRCULAR SHAFT-SINKING.—A new circular shaft has been started on the property of the Government Areas. The estimated depth will be 3,500 ft. The shaft, 22 ft. inside diameter, is expected to cost £125,000. In the light of pre-war figures for deep rectangular timbered shafts, this estimate of £35 15s. per foot (including general charges) seems moderate enough, and will demand high efficiency and freedom from serious water troubles.

THE QUARTER'S LOSSES.—The present is the period of annual meetings and reports, covering a year of great early prosperity and late decline. The first quarter of the current year, responsible for less than a month's normal tonnage, shows only five profit-earners :—

	Profit.
	£
Government Areas	51,066
Meyer & Charlton......	6,252
Modder Deep..........	52,874
New Modder...........	38,695
Van Ryn Deep...... ..	1,019

The total working losses were £1,233,000 for the quarter, including all strike expenditures. Assuming a normal profit of £2,000,000 for the quarter, the true cost of the strike to the industry is seen to have been a round million sterling per month.

Commissions of Inquiry.—Two commissions or boards of inquiry are now sitting upon the Rand. One, called the Martial Law Commission, is inquiring into the strike revolution. The other, the Mining Industry Board, is sitting in judgment upon the deep industrial questions, upon the sound solution of which the economic fate of the mines depends materially for years to come. Condensed, the terms of reference cover :—

(1) The status quo agreement (restriction of native labour in certain employments) ;

(2) Establishment of ratio between white and native labour ;

(3) Mining efficiency and economy, with maximum field for white labour ;

(4) The possibility of classifying the gold mines into two or more grades, and of applying different regulations and systems to each ;

(5) The recent colliery dispute.

PERTH, W.A.

April 21.

Prospecting Schemes.—The mark-time policy in mining, due to the general labour unrest and the low price of base metals, together with the decrease in the premium on gold, is felt in West Australia as well as in other countries. The Government realizes this, and in order to try and encourage the prospecting of country outside the beaten track, has given the Prospecting Board authority to carry out a portion of a scheme recommended by it some time ago. It is not quite so complete as the Board hoped, in that there is not a mining geologist included in the party. The reason is that all the available mining geologists in this State have been secured by various companies to take charge of the prospecting work on the oil concessions in the north-west of West Australia. As a result the Board had to choose as leader a sound prospector, who has a good working knowledge of rocks and minerals. His party of nine prospectors will include several returned soldier prospectors, who went through the course of training in scientific prospecting described in the November and December, 1919, issues of the Magazine. The leader, J. W. Jones, late Captain Royal Engineers, who although an Australian prospector, was in England in 1914 when war broke out, and went to France with the first batch of tunnellers. As the Board has had over a hundred experienced prospectors to choose from as members of the party, Capt. Jones will start off this expedition better supported and equipped than any party that has gone out to prospect the somewhat dry area east and north-east of Kalgoorlie. They will be away from civilization for twelve months, and food and water will be carried into the base camp by camels, while the detail prospecting will be done using horses and carts.

The area, extending over a width of 60 miles, will be temporarily reserved, so that any discovery made will go to the members of the party. After the party's reward ground is granted, the Government will make the best arrangements possible to recoup itself for the cost of the expedition by the leases granted subsequently to the public. The Geological Survey mapped out the country in a general way, and it will be the duty of the leader of the party to supply details to the Government Geologist, together with samples of rocks and minerals, so that the information gained can be recorded at the Mines Department for future guidance.

The Prospecting Board consists of the Government Geologist, State Mining Engineer, two representatives of the Prospectors' and Returned Soldiers' Associations, two mining engineers representing English and Australian capital, and the Assistant Secretary for Mines, who will watch the interests of the Mines Department and the public. Any discoveries made will be inspected by a mining engineer, possibly one of the members of the Board, so that the public, who in this case is paying the piper, will be sure of getting a better run for their money than has too often been the case in the old method of haphazard prospecting by small syndicates.

Wages Arbitration.—The main interest in gold-mining circles at present is centred in the holding of the Arbitration Court at

Kalgoorlie on the application of the Chamber of Mines for a reduction in the award which expired in December last. It can be assumed that the precedent of the railwaymen's award given last week, by which a reduction was made, will be followed in the miners' case. If such be the case development work at several points, which has been hung up, will be gone on with.

MINE TAXATION.—During the last session of both State and Federal Parliaments a certain amount of relief was given to mining in the taxation of prospectors and prospecting companies. In previous legislation the transfer of a mining lease was assessed for taxation purposes; in one case a new company had to pay several thousand pounds in such tax, before it produced an ounce of gold. The new Act sought to remedy this, but in the hurried redrafting due to alterations suggested by the Senate, in the Federal Parliament, the relief was only given to a bona fide prospector, and the decision of the bona fides of each prospector is to be decided by the Income Tax Commissioner *after* the lease has been sold. The Mining Association of Western Australia has taken advantage of Mr. Hughes' (Prime Minister of Australia) visit to this State to discuss the matter with him, and he stated that provided a prospector or syndicate backing such prospector or company having purchased a lease and worked it in a bona fide manner and who did not make a business as an agent of buying and selling leases would not be liable for a tax on the transfer of a lease. If Mr. Hughes can have this incorporated in the Federal Act it will bring it into line with the recently amended State Act.

PARLIAMENTARY AGITATION.—The Primary Producers' Association, which was formed as a political party to secure representation in Parliament, has four mining engineers on its executive council representing the mining industry, three of whom (J. S. Allen, C. M. Harris, and W. G. Sutherland) are members of the Institution of Mining and Metallurgy. It must be recognized that, however much a mining engineer hates public life, unless some members take up the burden and fight for the rights of investors, legislation will be brought in by members of Parliament who, while representing mining constituencies, do so mainly in the interests of labour.

PETROLEUM PROSPECTING.—The Assistant State Mining Engineer, Mr. T. Blatchford, who has been lent by the Government to the Treney Oil Company, has landed at Derby with his party, and will be proceeding at once to Mount Wynne to make a geological survey of the area granted to the company. Two boring plants capable of drilling to 4,000 ft. will be at Mount Wynne in a few days' time to start operations under Mr. Blatchford's supervision. Mr. Talbot, late of the Geological Survey, will carry out the topographical work on the area.

Mr. L. J. Jones, Assistant Government Geologist, N.S.W., has been lent by that State to the Kimberley Petroleum Co., to make as far as possible this year a geological survey of the area secured by this company. His assistant, Mr. H. P. Buckley, was one of Professor Sir Edgeworth David's most brilliant pupils. Geologists from other Australian Universities and Geological Survey Departments have been requisitioned for work in the north-west of this State. Never before has the public been taught to realize the value of the economic geologist, not only in mining but also as the director of prospecting operations for oil and non-metallic minerals.

TORONTO

May 10.

INCREASE IN GOLD PRODUCTION.—The gold output of the Porcupine and Kirkland Lake areas during April reached the highest point so far attained in the history of the Northern Ontario mining industry. According to preliminary estimates the total amounted to approximately $1,700,000. Porcupine was represented by three producers, the Hollinger, Dome, and McIntyre, which yielded about $1,475,000, and five mines in the Kirkland Lake area, the Lake Shore, Wright-Hargreaves, Teck-Hughes, Kirkland Lake, and Kirkland Lake Proprietary (1919) produced approximately $215,000.

THE POWER PROBLEM.—The question of securing an adequate supply of electric power to meet the steadily increasing requirements of the gold mines is in a fair way of solution. Satisfactory progress is being made with the work of developing power at Sturgeon Falls on the Mattagami River. It is expected to be completed early in December, which will secure the Porcupine mines against a shortage next winter. The Hollinger Consolidated has for some time planned the establishment of their own power system, and it is understood that they have secured from the Provincial Government the right to develop the Three Carrying Places rapids on the Abitibi River, where 40,000 h.p. can be generated. Although further removed from the mine than the power originally applied for by the company, the locality can be more economically developed. The present cost of power at the Northern Ontario mines ranges from about 35c. to 50c. per ton treated, the lower figure representing the cost where operations are on a large scale.

PORCUPINE.—The Dome Mines established a new high record during April with a production of $377,438, from the treatment of 27,354 tons of ore, the average grade of which was over $14 per ton, and the extraction $13·76 for each ton treated. The net profit is approximately estimated at $250,000. The profits for the year ended March 31 were $633,309, as compared with $302,479 for the preceding year. Diamond-drilling operations continue to indicate large bodies of ore lying beyond the present points of development, some of which are stated to show very high gold content. The Hollinger Consolidated now takes the lead as the greatest producer of precious metal in Canada, its output up to the end of March reaching an aggregate of approximately £44,000,000. Dividends so far paid amount to £17,542,000. The mill is now handling 3,700 to 4,000 tons of ore per day, with a production ranging from $32,500 to $35,000. At the Davidson Consolidated an ore-body has been encountered by diamond-drilling on the 1,050 ft. level, stated to assay $8 to the ton over a width of 25 ft. The Porcupine Vipond-North Thompson is being unwatered, and operations will be started on the North Thompson claim this month. The main vein has been driven on for about 100 ft. at the 600 ft. level, and the ore is found to carry an average of $9·40 per ton across a width of 11 ft. The Nipissing has cancelled its option on the Rochester property after extensive exploration by diamond-drilling. Gold was found at considerable depth, but results were not considered sufficiently encouraging to warrant the purchase. The Night Hawk Peninsular mines, capitalized at $5,000,000, owning mining properties aggregating 1,800 acres, has undertaken development work on the Porcupine Peninsular property where a shaft has been sunk to a depth of 265 ft. and two levels opened with promising results.

KIRKLAND LAKE.—Deep mining is becoming more general in this district and the physical condition of the mines shows improvement as greater depth is reached. Within the next two months the Teck Hughes will be working at a depth of about 1,000 ft.; the Wright-Hargreaves will be developing at a depth of 700 ft., and the work of carrying the shaft of the Kirkland Lake from the present 900 ft. level to 1,150 ft. or more will be under way. The Lake Shore is operating at 600 ft. deep, and the Kirkland Lake Proprietary is down 500 ft. The Teck Hughes during April treated an average of 162 tons of ore daily during the twenty-six days, when the plant was in operation, the estimated grade of the ore being $10 per ton. A new vein has been cut at the 730 ft. level, which is from 6 to 8 ft. wide, containing 2 to 4 ft. of high grade. The Lake Shore during March handled 2,210 tons of ore yielding an average of about $24·83 per ton. The shaft of the Sylvanite will shortly reach the 520 ft. level, where a station will be cut. The new electrically driven hoist is in operation, and extensive lateral work at this depth is planned. The main ore-body has been cut at the 390 ft. level. At the Wright-Hargreaves production during March was maintained at the normal rate of about $65,000, though some delay was caused by the breakage of one of the crushers, which has now been repaired. The merger of the Montreal-Kirkland and the Ontario-Kirkland mines has gone into effect, the new company, known as the Montreal-Ontario Mines, Ltd., being capitalized at $5,000,000. The plan of operations adopted involves an extension of the underground work accomplished on the Ontario-Kirkland, where good ore has been blocked out on three levels.

COBALT.—The Nipissing during March mined ore of an estimated net value of $172,747, and shipped bullion of an estimated net value of $362,441. The amount of cobalt produced was 24,936 lb. At the annual meeting General Manager Watson stated that the mine would probably produce nearly $3,000,000 worth of silver during the current year, realizing close to $1,000,000 net profit. The McKinley-Darragh, which has been closed since December, 1920, will be reopened about the middle of May. The company has about 25,000 tons of broken ore to start with. Litigation between M. J. O'Brien, Ltd., owners of the O'Brien mine, and the La Rose Mines over a boundary dispute has been in progress over two years.

A decision favourable to the O'Brien was appealed to the Supreme Court of Canada, which confirmed the judgment of the lower court and dismissed the appeal with costs. At the Victory a shaft is being put down to the 475 ft. level, which is directly above the contact between the diabase and Keewatin formations, at which level lateral work will be undertaken to tap the downward continuation of veins found on the upper levels.

West Shining Tree.—Activity in this district is increasing. Diamond-drilling is being carried on at the Atlas to test the downward extension of the high-grade lode known as the Evelyn vein. At the White Rock adjoining development on the 175 ft. level indicates a continuation of the Evelyn vein into this property. The Ribble, formerly the Wasapika, is preparing to start operations.

VANCOUVER, B.C.

May 11.

Consolidated Mining and Smelting.—The annual report of the Consolidated Mining and Smelting Company of Canada, which has recently been issued, shows that, after the expenditure of $232,692 for operating account, writing off $105,356 for capital renewals and depreciation, and providing $231,596 for bond interest and exchange on coupons, the company made an operating profit of $338,447, of which $256,690 was obtained from dividends from the West Kootenay Power & Light Co., a subsidiary company, and $81,487 from mining and smelting operations.

From a metallurgical view the past year has been the most successful in the history of the company, for it has been established that the mines and plant can be operated at a profit under the most trying conditions that ever have affected the mining industry. It has been demonstrated beyond doubt that the Sullivan lead-zinc ore can be economically concentrated. The concentrator is treating on an average 1,000 tons of ore daily, and costs have been reduced and recoveries have been increased. Most of the tonnage treated at the lead-smelter was concentrate from the Sullivan ore and residues from the zinc plant, and the metallurgists have succeeded in smelting a mixture higher in zinc than any other plant is treating. During the greater part of the year the zinc plant was short of an adequate supply of ore, owing to a change in the character of the Sullivan ore, which is gaining in lead and silver and losing in zinc.

Granby Consolidated.—The Granby Consolidated Mining Smelting and Power Co. has let a contract for the dam for its new reservoir on Falls Creek, 1½ miles above the old reservoir, to the Dredging and Contract Co., of Vancouver, the figure being in the neighbourhood of $350,000. The dam, which is of the multiple arch type, was designed by J. S. Eastwood, of Oakland, California. It will have a maximum height above the creek-bed of 138 ft., and a maximum length of 640 ft. It is expected that the reservoir will be completed by the end of September, and the necessary connexions made with the power-house by the end of the year. The whole improvement, together with additions that are to be made to the power plant, will cost about $500,000. To finance this expenditure and at the same time to retire some of its existing bond issue the company is offering its shareholders 30,000 shares of new stock at $25, the present quotation being about $27. The new stock is to be distributed on the basis of one share for every five of old stock. The company's present power plant is capable of developing 7,325 h.p., but it is largely dependent on stored water, which in the past has often been inadequate, consequently from two to five months in the year the plant often has either to be supplemented by steam power, or, as in the case of the first few months of the present year, production has had to be curtailed. It is estimated that the new reservoir will so cheapen the cost of production of copper that it will pay for itself within two years. During April of this year the Granby company made a new high record by smelting 91,123 tons of ore in the month.

Britannia.—The Britannia Mining and Smelting Co. is expediting the construction of its new concentrator plant, and the manager expects to have it in operation before the end of the present year. The company is building new houses for its employees, to replace those that were destroyed by the flood last autumn. It will be noticed that the two big copper companies of the Province have implicit faith in the future of the metal, for the Britannia is spending a million and the Granby half a million on improvements.

Cariboo.—The rush to the Cariboo goldfield continues, and already complications and lawsuits have arisen from the haphazard staking described in my last letter. Tales of new discoveries are coming from the field, but it is impossible to verify them. The season is unusually late, and much snow remains on the ground still. It is said that an area of ground more than 20 miles long and from 3 to 6 miles wide is practically covered by stakes. When the ground is surveyed, if, indeed, it ever is, for it will be a prodigious work, there will be found to be much overlapping of claims.

THE 1921 OUTPUT.—The annual report of the Minister of Mines for the year ended December 31, 1921, was issued in Victoria on April 20, and gives the following as the mineral production of the Province for the year, side by side with those of the two previous years, for the sake of comparison.

	1920.	1921.
Gold placer ....Oz.	11,080	11,660
,, lode..........Oz.	120,048	135,663
Silver ....Oz.	3,377,849	2,637,389
Copper.............Lb.	44,887,676	39,036,993
Lead ....Lb.	39,331,218	41,402,288
Zinc ....Lb.	47,208,268	49,419,372
Coal.........Long Tons	2,595,125	2,483,995
Coke.........Long Tons	67,792	59,434

As was anticipated, the production shows a considerable decrease compared with that of last year, a decrease that would have been much greater but for the remarkable production from the Premier mine. The great bulk of the metalliferous production was made by four companies. The Consolidated Mining and Smelting Co. produced 44,980 oz. of gold, 606,815 oz. of silver, 2,277,392 lb. of copper, 36,066,820 lb. of lead, and 49,319,198 lb. of zinc, from 387,623 tons of ore from its own mines, the Granby Consolidated Mining Smelting and Power Co. produced 7,652 oz. of gold, 313,204 oz. of silver, and 34,067,185 lb. of copper from 896,802 tons of ore; the Belmont-Surf Inlet Mines, Ltd., produced 44,980 oz. of gold, 20,706 oz. of silver, and 744,632 lb. of copper from 134,570 tons of ore; and the Premier Gold Mining Co. produced 40,104 oz. of gold and 1,117,978 oz. of silver from 18,750 tons of ore. It will be noticed that the Premier ore is far richer than is produced at any of the other mines.

YUKON TERRITORY.—An important new silver strike has been made on the Crœsus claim, Erickson gulch, Keno Hill district. The vein averages 3 to 6 ft. wide, and gives an average assay of 500 oz. per ton in silver. Some of the ore runs over 6,000 oz., which is the highest grade ore than has been found in the district. Up to April 17, the Yukon Gold Co. had shipped 3,300 tons of ore to Mayo Landing, awaiting shipment.

PERSONAL

JOHN F. ALLAN has moved his office to Bush Lane House, Cannon Street, London, E.C. 4.

W. L. BAILLIEU has left Australia on a visit to England, travelling by way of the United States.

S. G. BLAYLOCK, general manager for the Consolidated Mining and Smelting Company of Canada, has been appointed to a seat on the board of directors.

EDGAR BONDS has left for Siam.

C. B. BRODIGAN is here from South Africa.

E. W. BYRDE is here from Nigeria on holiday.

G. W. CAMPION is here from West Africa.

A. R. CANNING is home from Nigeria.

W. L. CASTLEDEN left for South Africa on May 13.

G. M. CLARK is here from South Africa.

A. W. DAVIS, lately manager of the Dolly Varden mine, has been appointed Provincial Resident Mining Engineer for the Ashcroft and Vernon mining divisions of British Columbia.

W. R. DEGENHARDT is home from Burma.

IVAN J. A. DIAMOND is leaving Kambove for Johannesburg, and is intending to come to England in July.

J. V. N. DORR and WILLIAM RUSSELL have been on a brief visit to Germany.

J. G. FOLEY has left for Nigeria.

ARTHUR FRANCIS is here from Kalgoorlie.

BERTRAM J. GILLARD left for South-West Africa on May 27.

B. B. GOTTSBERGER has been appointed professor of mining at Yale.

ALFRED JAMES has returned from Mexico.

G. C. KLUG is here from Australia.

J. G. LAWN is here from Johannesburg.

BRIAN LLEWELLYN has left for Colombia to take up an appointment at the Frontino and Bolivia gold mines.

H. F. MARRIOTT has resigned his position of consulting engineer in London to the Central Mining and Investment Corporation.

E. P. MATHEWSON has been invested with the Third Order of the Rising Sun by the Emperor of Japan, and has been elected an honorary member of the Mining Institute of Japan. At the anniversary meeting of the McGill University, his alma mater, the honorary degree of doctor of laws was conferred on him.

Dr. R. B. MOORE, chief chemist of the United States Bureau of Mines, is touring England and Europe.

Sir WILLIAM NOBLE, who has just retired from the position of Engineer-in-Chief to the Post Office, has accepted a seat on the board of the General Electric Co., Ltd. We understand that he proposes to devote his attention mainly to the development of the telephone and wireless sections of the company's business.

WALLINGTON A. POPE has returned from Nigeria.

E. C. POWIS is home from Nigeria.

W. A. PRICHARD is here from Colombia.

EDGAR RICKARD has been here from the United States, and has gone to Russia as director-general of the American Relief Association.

H. M. RIDGE is leaving for South Africa.

JAMES SHEA has returned from Nigeria and has left for South America.

J. L. SIDDALL has gone to South Africa.

W. E. SIMPSON is now at Kenogami Lake, Ontario.

ALBERT P. SNELLING is returning from Nigeria.

Sir E. A. SPEED has been elected chairman of the Naraguta (Nigeria) Tin Mines, Ltd., and Sir GEORGE DENTON has joined the board.

L. C. STUCKEY has left for Spain.

W. E. THORNE has arrived from the United States.

ALBERT J. TRAVIS has returned from Nicaragua.

J. B. TYRRELL has left on his return to Canada.

CHUNG YU WANG, of Hankow, has been awarded the Peter Le Neve Foster Prize of the Royal Society of Arts, for his paper on the Mineral Resources of China.

ERNEST R. WOAKES has been elected a director of Balaghat Gold Mines, Ltd.

FRANK YEATES has accepted a position with the Dorr Company.

H. H. YUILL left for Canada on May 25.

H. W. PRIDGEON, manager of West Springs, died on April 22.

F. N. BEST, a well-known director of Nigerian tin companies, died in Australia last month.

Dr. ELLIS T. POWELL, for some years editor of the *Financial News*, died last month in his 54th year.

Sir J. D. REES, M.P., director of several Indian gold mining companies, and chairman of the Champion Reef, was killed by an accident in the train last month, while travelling to Scotland.

NICHOLAS TRESTRAIL, of Redruth, died on May 23, aged 63. He was connected as consulting engineer with many mining ventures, and he was a specialist on pumping. He was elected an associate member of the Institution of Civil Engineers in 1894, and a member of the Institution of Mining and Metallurgy in 1912.

WILLIAM RICH died last month in London. He was a Cornishman and his father, brothers, and sons were or are connected with mining. He was best known as manager of the Rio Tinto mines, a position which he held from 1888 to 1900. Latterly he was chairman and managing director of the Namaqua Copper Company.

HENRY MARION HOWE, the distinguished American metallurgist, died last month at the age of 74. He was a graduate of Harvard and of the Massachusetts Institute of Technology. In 189) the late Richard P. Rothwell induced him to become a member of the editorial staff of the *Engineering and Mining Journal* in order that he should write on the metallurgy of steel. Thus he commenced to write a book on this subject, and it was published in instalments as a supplement to that paper. He did not stay long enough on the staff to finish the work, and the reprinted articles, "The Metallurgy of Steel," constituted an incomplete treatise. Subsequently he became professor of Metallurgy in Columbia University, New York. He resigned this position in order to devote his life to the writing of a comprehensive treatise on the metallurgy of iron and steel. He issued the first of a contemplated series of books in 1916 entitled "The Metallography of Steel and Cast Iron." Thus his literary labours have been incomplete, as were those of Dr. Percy, whom he resembled in many other ways. A deliberate thinker and original investigator and a sympathetic student of other men's work, he had an extraordinary power of presenting his views and his information with great completeness, clearness, and precision. The American iron and steel industry owe him a big debt for his teaching and advice in connexion with modern metallurgical principles.

TRADE PARAGRAPHS

The *Engineer* for April 28 contained an illustrated description of the rotary pneumatic motors for coal-cutters, mine hoists, etc., made by the SULLIVAN MACHINERY COMPANY.

HADFIELDS, LTD., of Sheffield, are supplying their disc crushers for the crushing department of the New State Areas metallurgical plant, these crushers taking the place of stamps. The same firm are supplying the preliminary jaw breakers.

M. B. WILD & Co., LTD., of Nechells, Birmingham, are introducing a new all-round band-brake for winding and hauling engines. A description of a brake of this kind at a South Wales colliery is given in the *Iron and Coal Trades Review* for May 12.

THE WESTINGHOUSE ELECTRIC AND MANUFACTURING CO., of East Pittsburg, Pennsylvania, send us descriptions of an improved form of Westinghouse-Shurvent electric fuse, of copper cooling coils for water-cooled transformers, and of a demand attachment for watt-hour meters.

HYATT, LTD., of 56, Victoria Street, London, S.W. 1, have issued a new general catalogue of their roller bearings as applied to various classes of industrial machinery. To the mining engineer this type of anti-friction bearing is applicable in many ways, and its use is fruitful of reductions in power costs.

EDGAR ALLEN & CO., LTD., of the Imperial Steel Works, Sheffield, send us their *Edgar Allen News* for May–June. This contains descriptions of plant made for the Basset process for making iron and steel direct from the ore to be shipped to the Basset works in France, of stone-working machinery, and of heat-treatment for the firms' "Stag" drill steels.

NOBEL INDUSTRIES, LTD., of Nobel House, London, S.W. 1, are exhibiting their plastic wood at the Foundry Trades Exhibition to be held at Birmingham from June 15 to 24. Particulars of this wood as applied to the wood-working industries and furniture manufacture have already been given in these columns. Its application to the making of foundry patterns is of equal importance.

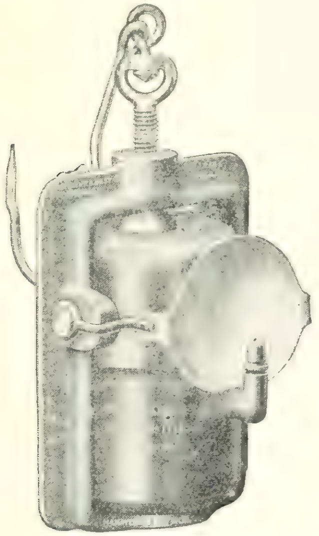
MINERALS CONCENTRATION CO., LTD., of 4, London Wall Buildings, London, E.C. 2, have supplied one of their Richardson rotary concentrators, with gravel pump, for work on an alluvial gold property in Spain. Though this gold is very fine it is mostly granular in form and in a bulk test responded in a highly satisfactory manner to the company's method of treatment. This plant is a pilot installation to be used in proving the ground and the method of concentration. If expectations are realized the intention is to supply a bucket-dredge on which will be fitted Richardson rotary concentrators.

THE BURY COMPRESSOR CO., of Erie, Pennsylvania, send us a catalogue of their Universal Air-Compressors, which are described as the three-cylinder two-stage universal variable-volume duplex-compound compressors. The following are the special features of the design: Automatic flood lubrication of cross-heads, main bearings, and all moving parts; liberal bearings ensuring smooth running for hard, continuous service; complete and careful water-jacketing providing efficient cooling; enclosed frames with removable covers ensuring cleanliness and accessibility; balanced cranks and heavy fly-wheel ensuring steadiness in operation; heavy duty solid main frame ensuring rigidity and strength throughout;

installation made on simplest foundation; Bury Universal Pyramid box-plate valve, "durable as the Pyramids and silent as the Sphinx."

The Westinghouse Electric & Manufacturing Company, of East Pittsburgh, U.S.A., have been awarded the contract for electrical equipment for a new power-house to be constructed by the Southern California Edison Company and to be known as Big Creek No. 3. The contract calls for vertical water-wheel generator units and also transformers, auto-transformers, high-tension circuit-breakers, and miscellaneous auxiliary and switching equipment for 220,000 volts. The equipment covered by the contract is for the initial installation at a new power station in the Big Creek district. The plant, which will have an ultimate capacity of 150,000 kw., will tie in the present plants in the Big Creek district feeding the 275 mile transmission line to Los Angeles. The units to be built are of the largest capacity so far to be installed by the Southern California Edison Company, and the plant, which will be the fourth to be built in the Big Creek development, will be the largest on this extensive hydro-electric generating system.

Ackroyd & Best, Ltd., of Morley, near Leeds, are introducing on the market their Hailwood Clamp acetylene lamp. The water container and the carbide container are held in position by the Hailwood clamp, which encircles both containers and a screw or cam clamp bears down on the water container, thus ensuring good joints. Both containers are simple cups, free from all clamp-fittings.



The Hailwood Clamp Acetylene Lamp.

When assembling, the water container is placed upon the carbide container and the whole is slipped into the clamp. The clamp is fitted with a handle and with an upward swinging reflector. One of the advantages of this design is that the carbide container, which generally wears out first, can be simply and cheaply replaced.

The Bucyrus Company, of South Milwaukee, Wisconsin (London office: Iddesleigh House, Caxton Street, S.W. 1) have recently introduced a mechanical shovel driven by a petrol engine or by a Diesel engine. Some years ago they applied a petrol engine to their drag-line excavators, but the revolving digger hitherto driven by steam or electricity presents a more difficult problem. The company have now solved these difficulties, and it is believed that the new shovel is simpler than the steam or electrically-driven shovel. There is only one engine, as compared with three in the steam shovel and five on the petrol-electric shovel. Moreover, with the one engine there are only four operating clutches. A small drum mounted on the shipper shaft is sufficient to control all the motions of the dipper, and by this design all the power-transmission problems of the thrust have been solved. The boom is shaped in such a manner as to obtain a greater pull on the dipper. It is possible thus to obtain the quick sharp reversals of the dipper essential when shaking stiff clay from the dipper. As recorded last month, this type of shovel was designed for the use of petrol, but more recently a Diesel engine has been applied, and by this means it is believed that the machine will be acceptable in out-of-the-way places, and will be able to work very cheaply.

METAL MARKETS

Copper.—Prices of standard copper in London had a distinctly upward tendency during May, a rise of about 60s. being recorded. This was almost entirely due to the firmness of the market for electrolytic in New York, which naturally acted as a strengthening factor on this side. Holders and producers in America have created an artificial scarcity of copper for domestic use by earmarking for export a large block of the metal available; and since fresh production from the newly reopened mines will not be arriving in sufficient quantities to disturb the balance of the market for some months to come, American consumers are forced to pay stiff prices. During the month under review electrolytic rose from 13 to 13⅞ cents per lb. Meanwhile, in London, dealers and consumers became apprehensive lest standard should rise in proportion; and considerable purchasing of near metal and bear covering materialized, with the result that the contango narrowed almost to vanishing-point at one time, and prices rose appreciably. The buying movement in this country cannot be said to have been the result of any substantial improvement in trade, however, and it is felt that if the American interests are unable to maintain their quotation at its present level, standard values might possibly recede again. Nevertheless, no serious setback is anticipated, as there is a considerable body of opinion which considers standard copper as reasonably priced at around current figures.

Average price of cash standard copper: May, 1922, £61 2s. 9d.; April, 1922, £58 17s. 2d.; May, 1921, £73 5s. 10d.; April, 1921, £69 8s. 11d.

Tin.—At the beginning of the month standard tin had an easy tendency, and it seemed likely that values might recede considerably, in view of the none too brilliant outlook. The fall, however, only amounted to a few pounds, and by the middle of the month a decidedly better tone came into existence, thanks to a certain amount of American support. The last fortnight witnessed a gradual recovery in quotations, with the result that closing prices were slightly up on the month. Sentiment during May was somewhat subdued, and the market generally was characterized by only a moderate daily turnover. Demand from South Wales and Continental consumers was small but steady, while the United States bought spas-

Daily London Metal Prices: Official Closing
Copper, Lead, Zinc, and Tin per Long Ton

	Copper				
	Standard Cash	Standard (3 mos.)	Electrolytic	Wire Bars	Best Selected
May	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d.	£ s. d. £ s. d.
10	60 0 0 to 60 2 6	60 7 6 to 60 10 0	65 0 0 to 67 0 0	67 0 0	— —
11	60 2 6 to 60 5 0	60 7 6 to 60 10 0	65 10 0 to 67 10 0	67 10 0	— —
12	60 2 6 to 60 5 0	60 10 0 to 60 12 6	65 10 0 to 67 10 0	67 10 0	63 10 0 to 65 10 0
15	62 6 3 to 60 7 6	69 13 9 to 60 15 0	66 0 0 to 68 0 0	68 0 0	— —
16	60 10 0 to 60 12 6	60 16 3 to 60 17 6	66 0 0 to 68 5 0	68 5 0	64 0 0 to 66 0 0
17	61 0 0 to 61 1 3	61 3 9 to 61 5 0	66 5 0 to 68 5 0	68 5 0	— —
18	61 16 3 to 61 17 6	61 17 6 to 62 0 0	67 0 0 to 69 0 0	69 0 0	— —
19	62 2 6 to 62 5 0	62 5 0 to 62 7 6	67 10 0 to 69 10 0	69 10 0	65 10 0 to 67 10 0
22	61 17 6 to 62 0 0	62 5 0 to 62 7 6	68 0 0 to 70 0 0	70 0 0	— —
23	62 2 6 to 62 5 0	62 10 0 to 62 12 6	68 10 0 to 70 10 0	70 10 0	66 0 0 to 68 0 0
24	62 5 0 to 62 7 6	62 12 6 to 62 15 0	68 10 0 to 70 10 0	70 10 0	— —
25	62 7 6 to 62 10 0	62 15 0 to 62 17 6	68 10 0 to 70 10 0	70 10 0	— —
26	62 5 0 to 62 7 6	62 13 9 to 62 15 0	68 10 0 to 70 0 0	71 0 0	66 0 0 to 68 0 0
29	62 7 6 to 62 10 0	62 15 0 to 62 17 6	68 10 0 to 71 0 0	71 0 0	— —
30	62 12 6 to 62 15 0	63 0 0 to 63 2 6	68 10 0 to 71 0 0	71 0 0	66 10 0 to 68 10 0
31	62 15 0 to 62 17 6	63 2 6 to 63 5 0	68 10 0 to 71 0 0	71 0 0	— —
June					
1	63 2 6 to 63 5 0	63 10 0 to 63 12 6	69 10 0 to 71 10 0	71 10 0	— —
2	63 8 9 to 63 10 0	63 16 3 to 63 17 6	69 10 0 to 71 10 0	71 10 0	67 10 0 to 69 10 0
6	63 2 6 to 63 5 0	63 10 0 to 63 12 6	69 10 0 to 71 10 0	71 10 0	67 10 0 to 69 10 0
7	62 17 6 to 63 0 0	63 5 0 to 63 7 6	69 10 0 to 71 0 0	71 0 0	— —
8	62 7 6 to 62 10 0	62 15 0 to 62 17 6	69 10 0 to 71 0 0	71 0 0	— —
9	62 0 0 to 62 2 6	62 7 6 to 62 10 0	69 10 0 to 71 0 0	71 0 0	67 0 0 to 69 0 0

modically. There are apprehensions that the continued coal stoppage in America may shortly adversely affect the operations of the tinplate mills, with a consequent diminution in tin purchases, while, furthermore, it is known that the United States is pretty well stocked for the time being, so that there is little prospect of much heavy buying from that quarter in the near future. It is realized that under these circumstances the London market is unlikely to display a very firm aspect. Another factor which had not latterly assisted confidence was the anticipation that the statistical position would show up unfavourably when the figures were published at the beginning of June. As a matter of fact, however, the statistics revealed an increase of 1,000 tons in the visible supplies, with the result that sentiment has since undergone a little improvement.

Average price of cash standard tin: May, 1922, £150 5s.; April, 1922, £149 18s. 11d.; May, 1921, £177 10s. 8d.; April, 1921, £164 0s. 11d.

Lead.—Considerable control was exercised by holding interests over the London market during the month under review, with the result that prices were forced up to an appreciable degree. Quite good arrivals were seen early in the month, so that there was certainly no actual immediate shortage of lead, but a substantial portion of these shipments was received at provincial ports, the result being that the London market was to a certain degree starved. At times, indeed, metal was purchasable at cheaper figures in Liverpool than in London, and lead was occasionally transported from minor ports to meet the London demand. The net result has been that the London market has worn an artificial aspect and has temporarily ceased to be a reliable indicator of actual lead conditions. It must be admitted that there is little sign of any amelioration taking place in the position for some little time to come, since supplies from producing countries are likely to be restricted for some weeks at least, a fact of which the holding interests are certain to take full advantage. There is little doubt, however, that the present inflated price is adverse to consumers, and users continue to buy only against immediate needs; for prompt metal, however, a considerable premium over forward has to be paid. The Penarroya strike was reported settled early in the month, but stocks in Spain are practically exhausted, and there is no likelihood of any large shipments from that country just yet. Mexico, however, has a certain amount of lead available, while a fair quantity is afloat from Australia, which should shortly ease the position somewhat.

Average price of soft foreign lead: May, 1922, £23 16s. 7d.; April, 1922, £22 14s. 1d.; May, 1921, £23 7s. 3d.; April, 1921, £20 16s. 10d.

Spelter.—Despite a setback early in the month, values on the London market had an upward tendency on the whole, and an appreciable rise was registered on balance. Business on 'Change was spasmodic, interest being somewhat restricted, although at times a certain liveliness developed, accompanied by a large turnover. Demand and supply were hardly well balanced, since while neither buyers nor sellers were keen, the latter seemed to have control of the position, as was demonstrated by the rising tendency of prices. A certain amount of metal dribbled in from Belgium and Germany, but available supplies were none too generous, and the market is still denied the extra quantities which were anticipated to result from the expansion of world production. English makers are producing steadily and evince no desire to accumulate stocks; their output so far, however, is insufficient appreciably to affect the market position. The fact that Belgium has now contracted for a supply of some 450,000 tons of Australian concentrates should lead to a further increase in her output in the near future, while eventually the big Tasmanian works at Risdon should have their influence on the London market. In America the market has been pretty firm, and there seems little likelihood of any substantial offers from the United States for some time to come, at least.

Average price of spelter: May, 1922, £27 4s. 9d.; April, 1922, £26 10s. 10d.; May, 1921, £27 6s. 7d.; April, 1921, £26 1s. 5d.

Prices on the London Metal Exchange.
Silver per Standard Ounce; Gold per Fine Ounce.

Lead: Soft Foreign	Lead: English	Zinc (Spelter)	Standard Tin: Cash	Standard Tin: 3 mos.	Silver: Cash	Silver: Forward	Gold	
£ s. d. £ s. d.	£ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	£ s. d. £ s. d.	d.	d.	s. d.	May
24 7 6 to 23 0 0	25 10 0	27 2 6 to 27 0 0	148 17 6 to 149 0 0	150 5 0 to 150 10 0	35⅜	35⅝	93 5	10
24 5 0 to 23 5 0	25 10 0	27 0 0 to 27 0 0	148 15 0 to 148 17 6	150 0 0 to 150 2 6	35⅝	35½	93 6	11
24 2 6 to 23 0 0	25 10 0	27 0 0 to 27 0 0	149 7 6 to 149 10 0	150 17 6 to 151 0 0	35⅜	35⅜	93 7	12
24 0 0 to 23 0 0	25 5 0	27 0 0 to 27 0 0	149 5 0 to 149 10 0	150 15 0 to 150 17 6	36⅛	36¼	93 3	15
24 0 0 to 22 15 0	25 5 0	26 17 6 to 26 15 0	148 5 0 to 148 10 0	149 15 0 to 150 0 0	36⅜	36¼	93 2	16
24 0 0 to 22 17 6	25 5 0	27 0 0 to 26 17 6	148 15 0 to 148 17 6	150 0 0 to 150 5 0	36½	36½	93 2	17
24 5 0 to 23 2 6	25 10 0	27 2 6 to 27 0 0	150 5 0 to 150 10 0	151 15 0 to 152 0 0	37	37	93 2	18
24 10 0 to 23 2 6	25 15 0	27 5 0 to 27 0 0	152 10 0 to 152 12 6	154 0 0 to 154 2 6	36	36	92 11	19
24 17 6 to 23 7 6	26 0 0	27 5 0 to 27 2 6	150 10 0 to 150 12 6	151 17 6 to 152 0 0	37⅜	37⅜	92 11	22
25 2 6 to 23 10 0	26 5 0	27 5 0 to 27 2 6	149 15 0 to 150 0 0	151 5 0 to 151 10 0	36⅝	36⅝	93 2	23
25 5 0 to 23 10 0	26 5 0	27 10 0 to 27 7 6	150 10 0 to 150 15 0	152 0 0 to 152 5 0	36½	36½	93 4	24
24 17 6 to 23 7 6	26 5 0	27 12 6 to 27 10 0	151 0 0 to 151 5 0	152 10 0 to 152 12 6	36⅝	36½	93 5	25
25 0 0 to 23 7 6	26 0 0	27 17 6 to 27 15 0	150 7 6 to 150 10 0	151 15 0 to 151 17 6	36⅝	36⅝	93 5	26
25 0 0 to 23 10 0	26 0 0	28 2 6 to 27 17 6	151 0 0 to 151 2 6	152 5 0 to 152 7 6	36⅜	34⅜	93 3	29
25 2 6 to 23 11 3	26 5 0	28 2 6 to 27 17 6	152 2 6 to 152 7 6	153 10 0 to 153 12 6	36½	36½	92 9	30
25 5 0 to 23 15 0	26 5 0	28 2 6 to 27 17 6	152 7 6 to 152 10 0	153 15 0 to 153 17 6	36½	36½	92 9	31
								June
25 0 0 to 23 12 6	26 0 0	28 2 6 to 27 17 6	153 5 0 to 153 10 0	154 10 0 to 154 15 0	36¼	36¼	93 1	1
24 17 6 to 23 15 0	26 0 0	28 3 9 to 27 18 9	154 0 0 to 154 2 6	155 5 0 to 155 7 6	36⅜	36⅛	92 11	2
24 17 6 to 23 15 0	26 0 0	28 2 6 to 27 17 6	154 15 0 to 155 0 0	155 17 6 to 156 0 0	35¼	35⅛	92 1	6
25 0 0 to 23 17 6	26 5 0	28 0 0 to 27 15 0	154 7 6 to 154 10 0	155 10 0 to 155 12 6	35⅝	35⅝	91 6	7
24 17 6 to 23 17 6	26 5 0	28 2 6 to 27 17 6	153 7 6 to 153 10 0	154 10 0 to 154 12 6	35⅞	35¾	91 6	8
24 17 6 to 23 17 6	26 5 0	28 2 6 to 27 17 6	153 0 0 to 153 5 0	154 5 0 to 154 10 0	35¾	35⅝	91 9	9

Zinc Dust.—Prices are steady: Australian high-grade, £50 per ton, American 92 to 94% £47 10s., and English 90 to 92% £45. Lower grades can be obtained more cheaply.

Antimony.—Quotations have eased somewhat, English regulus being now £27 to £29 10s. for ordinary brands and £32 10s. to £35 for special brands. Foreign is still quoted at about £24 to £24 10s. ex warehouse for home consumption, while £23 would be accepted for export orders.

Arsenic.—The market is firm, with 99% Cornish white offering at about £42 10s. delivered London.

Bismuth.—Prices are steady, with 9s. per lb. quoted for 5 cwt. lots and over.

Cadmium.—A moderate business has been passing at the unchanged quotation of 5s. 9d. per lb.

Aluminium.—Domestic makers have modified their prices, quoting now £100 for home and £105 per ton for export. There is not much demand for foreign material, which is obtainable at around £85 f.o.b. Continent.

Nickel.—Values are steady at £162 10s. per ton for both home and export business. Foreign metal is priced at about £150 to £160 f.o.b. Continent.

Cobalt Metal.—The price is unaltered at 12s. per lb., with business dull.

Cobalt Oxides.—There is not much inquiry and prices are steady, grey oxide being quoted at 10s. and black at 9s. per lb.

Platinum.—Manufactured (sheets and wire), £19; raw, £17 per oz.

Palladium.—Business is quiet, with manufactured priced at £16, and raw metal at £12 10s. per oz.

Quicksilver.—The tendency in the market is firm owing to the reserve of the chief holders, but business is hardly brisk. The present spot price is around £11 10s. to £11 15s. per bottle.

Selenium.—The quotation is steady at 7s. 9d. per lb.

Tellurium.—Sellers quote down to 40s. per lb.

Manganese Ore.—Indian and Caucasian grades are quoted at 1s. 1½d. to 1s. 2d. per unit c.i.f.

Chrome Ore.—Values are rather better at about £4 5s. to £4 7s. 6d. per ton c.i.f.

Sulphate of Copper.—Values are rather firmer on the month at £27 to £27 10s. for both home and export business.

Tungsten Ore.—There is some demand, with 65% WO_3 offered at 12s. ex warehouse and 11s. 9d. per unit c.i.f. for early shipment.

Molybdenite.—Prices are mainly a matter of negotiation; we call 85% about 30s. to 35s. per unit c.i.f.

Silver.—On May 1 spot bars were quoted at 34⅞d., the price rising to 35¼d. on the 5th on Chinese support. A relapse to 35d. took place on the 6th, but later a fair amount of Indian and Chinese buying materialized, so that by the 18th the quotation was up to 37d. Some sales by the Continent were then witnessed, under the stress of which spot bars fell to 36d. on the 19th, but renewed Chinese support pushed the price up to 37⅜d. on the 22nd. This figure was not maintained, as a certain amount of selling came out, and the quotation eased to 36½d. on the 24th. The quotation closed the month at 36½d. on May 31.

Graphite.—Business is not active. Madagascar, 80 to 90% is steady at £16 per ton c.i.f.

Iron and Steel.—Improvement in the iron and steel trades has been hampered throughout the month by the continued unrest in the labour world, the engineering strike being still unsettled. Home buying of pig iron has accordingly been restricted, but ironmasters have been in a degree compensated by sales for export, quite a moderate amount of buying having been done by American consumers. The general position, however, is not bright, there being at the present time only 25 furnaces in blast in the Yorkshire district. Prices have remained unchanged, No. 3 G.M.B. being quoted at 90s. for either home or export. In finished iron and steel, business has been very slow, the home trade taking but little interest, while export sales have been subjected to a certain amount of competition from the Continent. Latterly, however, the home trade has shown signs of waking up, certain underground railway contracts having been placed, while other business is waiting a clearance of the industrial dispute.

STATISTICS

Production of Gold in the Transvaal.

	Rand	Elsewhere	Total	Price of
	Oz.	Oz.	Oz.	Gold per oz.
				s. d.
May, 1921	671,750	16,026	687,776	103 9
June	663,383	15,107	678,490	107 6
July	673,475	16,080	689,555	112 6
August	695,230	16,296	711,526	111 6
September	674,157	16,939	691,096	110 0
October	690,348	17,477	707,825	103 0
November	688,183	16,053	704,236	102 0
December	664,935	16,912	681,847	95 6
Total, 1921	7,924,534	190,052	8,114,586	—
January, 1922				95 6
February	594,788	44,940	639,728	92 6
March				94 0
April	493,402	17,936	511,338	92 0

Natives Employed in the Transvaal Mines.

	Gold mines	Coal mines	Diamond mines	Total
February 28, 1921	171,518	14,697	1,612	187,827
March 31	174,364	14,906	1,364	190,634
April 30	172,826	14,908	1,316	189,050
May 31	170,595	14,510	1,302	186,407
June 30	168,152	14,704	1,317	184,173
July 31	166,999	14,688	1,246	182,933
August 31	169,008	14,446	1,207	184,661
September 30	171,912	14,244	1,219	187,375
October 31	175,331	13,936	1,223	190,490
November 30	176,410	13,465	1,217	191,092
December 31	177,836	13,280	1,224	192,340
March 31, 1922	124,169	11,155	1,204	136,528
April 30	138,277	11,385	1,232	150,894

Cost and Profit on the Rand.

Compiled from official statistics published by the Transvaal Chamber of Mines. Figures for yield include premium.

	Tons milled	Yield per ton	Work'g cost per ton	Work'g profit per ton	Total working profit
		s. d.	s. d.	s. d.	£
April, 1921	1,991,815	34 5	25 10	8 7	854,533
May	1,955,357	35 3	26 2	9 1	889,520
June	1,966,249	35 10	25 10	10 0	979,769
July	2,010,236	37 2	25 7	11 7	1,163,565
August	2,050,722	37 3	25 4	11 11	1,226,282
September	1,997,086	36 8	25 2	11 6	1,151,127
October	2,041,581	34 4	24 9	9 7	981,597
November	2,007,617	34 6	24 9	9 9	978,931
December	1,954,057	31 11	24 11	7 0	683,565
Jan., 1922 / February / March	1,624,333	33 10	49 0	15 2*	1,233,033*

* Loss.

Production of Gold in Rhodesia.

	1920	1921	1922
	oz.	oz.	£
January	43,428	46,956	53,541
February	44,237	40,816	51,422
March	45,779	31,995	54,643
April	47,000	47,858	[illegible]
May	46,266	48,744	—
June	45,054	49,466	—
July	46,208	51,564	—
August	48,740	53,200	—
September	45,471	52,436	—
October	47,343	53,424	—
November	46,782	53,098	—
December	46,190	55,968	—
Total	552,408	591,525	[illegible]

Transvaal Gold Outputs.

	March		April	
	Treated Tons	Yield Oz.	Treated Tons	Yield Oz.
Aurora West	8,409	£10,668*	7,160	£9,606†
Brakpan	30,548	15,136	32,000	14,201
City Deep	55,600	32,162	69,200	27,033
Cons. Langlaagte	36,000	£51,710*	25,800	£35,612†
Cons. Main Reef	42,170	18,867	35,000	13,039
Crown Mines	146,600	53,104	146,400	43,666
D'rb'nRoodepoortDeep	27,393	8,091	24,500	8,183
East Rand P.M.	105,200	23,845	85,000	22,997
Ferreira Deep	20,960	5,430	15,900	4,464
Geduld	50,500	19,078	43,200	15,781
Geldenhuis Deep	35,936	9,962	38,223	10,160
Glynn's Lydenburg	4,370	£8,074§	4,076	£7,071‡
Goch	18,700	£19,558*	16,400	£15,262†
Government G.M. Areas	115,500	£263,579*	105,500	£217,503†
Kleinfontein	—	-	27,400	6,846
Knight Central	34,570	8,063	19,100	4,773
Langlaagte Estate	36,806	£49,654*	35,000	£55,145†
Luipaard's Vlei	—	—	—	—
Meyer & Charlton	14,522	£41,600*	11,000	£31,205
Modderfontein, New	65,000	40,406	61,000	28,801
Modderfontein B	47,000	23,082	40,000	20,700
Modderfontein Deep	56,600	32,955	40,100	20,561
Modderfontein East	13,750	5,919	17,600	8,136
New Unified	12,700	£9,937*	8,700	£8,397†
Nourse	43,550	13,367	34,100	11,421
Primrose	16,000	£17,028*	14,500	£15,100†
Randfontein Central	76,100	£105,896*	88,700	£118,669†
Robinson	20,300	6,715	11,500	4,471
Robinson Deep	52,300	£85,370*	39,700	13,224
Roodepoort United	14,707	£12,538*	8,850	£8,506†
Rose Deep	54,160	14,346	38,200	9,882
Simmer & Jack	59,900	£73,778*	29,700	8,472
Springs	27,690	10,468	30,900	13,635
Sub-Nigel	14,600	£46,347*	10,200	5,597
Transvaal G.M. Estates	16,290	£26,314§	15,560	£25,253‡
Van Ryn	24,058	£35,197*	21,150	£26,159†
Van Ryn Deep	45,210	£101,620*	36,500	£74,913†
Village Deep	43,150	13,596	45,500	14,796
West Rand Consolidated	39,440	£47,505*	32,000	£40,681†
Witw'tersr'nd (Knights)	47,420	£52,151*	25,280	£29,544†
Witwatersrand Deep	27,016	£41,691*	27,680	8,340
Wolhuter	32,055	7,249	26,500	6,313

The March figures for mines on the Rand include all crushings since January 1.

* £4 15s. 6d. per oz. for January; £4 12s. 6d. for February; £4 14s. for March. ‡ £4 10s. per oz. † £4 12s. per oz. § £4 12s. per oz.

Rhodesian Gold Outputs.

	March.		April.	
	Tons	Oz.	Tons	Oz.
Cam & Motor	14,100	6,530	14,600	5,383
Falcon	15,534	3,010*	15,840	3,243‖
Gaika	4,018	£7,303	4,049	£7,702
Globe & Phœnix	6,346	5,407	6,136	5,356
Jumbo	1,320	521	1,550	516
London & Rhodesian	4,339	£4,564	4,119	£4,264
Lonely Reef	5,570	4,957	5,650	4,982
Planet-Arcturus	6,020	2,305	5,600	2,095
Rezende	6,000	2,936	—	—
Rhodesia G.M. & I.	229	299	276	251
Shamva	59,000	£37,946‡	50,550	£38,077§
Transvaal & Rhodesian	1,650	5,160	—	—

* Also 277 tons copper. † At par. ‖ Also 298 tons copper.
§ Gold at £4 12s. 6d. per oz. ‡ Gold at £4 12s. 6d. per oz.

West African Gold Outputs.

	March		April	
	Tons	Oz.	Tons	Oz.
Abbontiakoon	8,400	£14,032*	8,000	£15,097*
Abosso	7,350	2,954	7,400	2,971
Ashanti Goldfields	7,677	6,575	7,072	5,496
Obbuassi	478	£1,910†	378	278
Prestea Block A	8,323	£15,085*	8,236	£14,826*
Taquah	2,990	1,757	2,800	1,611

* At par. † Including premium.

West Australian Gold Statistics.—Par Values.

	Reported for Export Oz.	Delivered to Mint Oz.	Total Oz.	Par Value £
August, 1921	110	51,731	51,841	220,205
September	380	50,728	51,108	217,092
October	1,910	51,286	53,196	225,959
November	156	46,429	46,585	197,879
December	451	53,348	53,799	228,522
January, 1922	329	37,851	38,180	162,177
February	926	41,194	42,120	178,913
March	180	42,842	43,022	182,745
April	1,237	45,157	46,394	197,068
May	271	39,454	39,725	168,740

Australian Gold Outputs.

	West Australia	Victoria	Queensland	New South Wales
	oz.	oz.	oz.	£
January	38,181	4,411	448	11,855
February	42,121	8,063	1,200	12,325
March	43,022	11,717	1,069	12,960
April	46,394	—	—	6,589
May	39,725	—	—	13,100
June	—	—	—	—
July	—	—	—	—
August	—	—	—	—
September	—	—	—	—
October	—	—	—	—
November	—	—	—	—
December	—	—	—	—
Total	209,443	24,139	2,717	56,829

Australasian Gold Outputs.

	March		April.	
	Tons	Value £	Tons	Value £
Associated G.M. (W.A.)	6,370	8,352‖	5,503	6,590‖
Blackwater (N.Z.)	3,871	7,911*	2,862	5,647*
Gold'n Horseshoe (W.A)	10,524	5,472‡	9,108	5,045‡
Grt Boulder Pro. (W.A.)	9,893	29,679‖	9,967	26,294‖
Hampton Celebr. (W.A.)	—	—	930	1,049
Ivanhoe (W.A.)	15,997	6,788‡	13,736	5,914‡
Lake View & Star (W.A.)	6,471	12,881‖	5,557	9,502‖
Oroya Links (W.A.)	1,418	6,401‖†	1,430	7,794‖†
South Kalgurli (W.A.)	7,256	12,442‖	6,376	11,215‖
Waihi (N.Z.)	12,868	3,699‡ / 11,484§	12,773	4,026‡ / 18,86[illegible]§
,, Grand Junc'n (N.Z.)	—	—	—	—

* Including premium; † Including royalties; ‡ Oz. gold; § Oz. silver; ‖ At par.

Miscellaneous Gold and Silver Outputs.

	March		April.	
	Tons	Value £	Tons	Value £
Brit. Plat. & Gold (C'lbia)	—	279*p*	—	200*p*
El Oro (Mexico)	35,028	188,326†	33,710	175,485†
Esperanza (Mexico)	—	1,760*e*	—	2077*e*
Frontino & Bolivia (C'lbia)	1,900	5,777	2,069	7,143
Keeley Silver (Canada)	—	59,000*s*	—	50,500*s*
Mexico El Oro (Mexico)	13,000	195,900†	13,070	184,530†
Mining Corp. of Canada	—	141,127*s*	—	101,538*s*
Oriental Cons. (Korea)	—	91,000†	—	89,500†
Ouro Preto (Brazil)	7,700	2,598‖	6,700	2,341‖
Plym'th Cons. (Calif'rnia)	8,000	9,609*	9,000	9,835*
St. John del Rey (Brazil)	—	44,000*	—	39,000*
Santa Gertrudis (Mexico)	33,289	58,156*e*	33,069	26,859*e*
Tomboy (Colorado)	18,000	71,000†	16,000	69,000†

* At par. † U.S. Dollars. ‡ Profit, gold and silver. ‖ Oz. gold. *p* Oz. platinum and gold. *s* Oz. silver. *e* Profit in dollars.
Nechi (Colombia): 46 days to May 2, $10,034 from 112,140 cu. yd.; 16 days to May 18, $15,135 from 92,726 cu. yd.
Pato (Colombia): 19 days to May 1, $21,524 from 115,056 cu. yd.; 19 days to May 20, $22,556 from 113,987 cu. yd.

Indian Gold Outputs.

	March		April.	
	Tons Treated	Fine Ounces	Tons Treated	Fine Ounces
Balaghat	3,250	2,482	3,150	2,533
Champion Reef	11,628	4,910	11,985	4,913
Mysore	18,318	10,502	18,265	10,502
North Anantapur	550	595	550	602
Nundydroog	9,636	5,028	9,352	5,026
Ooregum	13,000	8,598	12,900	8,493

Production of Gold in India.

	Reported by English mining companies.				Total.
	1918	1919	1920	1921	1922
	Oz.	Oz.	Oz.	Oz.	Oz.
January	41,420	38,184	39,073	34,028	35,493
February	40,787	36,384	38,872	32,529	34,690
March	41,719	38,317	38,760	32,576	—
April	41,504	38,248	37,307	32,363	—
May	40,889	38,608	38,191	32,656	—
June	41,264	38,359	37,864	32,207	—
July	40,229	38,549	37,129	32,278	—
August	40,496	37,850	37,375	32,498	—
September	40,088	36,813	35,497	32,642	—
October	39,472	37,138	35,023	32,186	—
November	36,984	39,628	34,522	32,293	—
December	40,149	42,643	34,919	32,578	—
Total	485,236	461,171	444,532	390,549	70,183

Base Metal Outputs.

		Mar.	April.
Broken Hill British	Tons lead carb. ore	385	510
	Tons lead conc.	2,750	3,443
	Tons zinc conc.	2,140	2,970
Broken Hill Prop.	Tons lead conc.	1,643	1,562
	Tons zinc conc.	6,105	3,251
Broken Hill South	Tons lead conc.	4,970	3,966
Burma Corporation	Tons refined lead	3,250	3,029
	Oz. refined silver	332,000	320,767
Electrolytic Zinc	Tons zinc	1,581	1,686
Mount Lyell	Tons copper	217	461
	Oz. silver	4,067	10,442
	Oz. gold	53	168
Mount Morgan	Tons copper	360	441
	Oz. gold	4,509	5,155
North Broken Hill	Tons lead conc.	1,960	1,760
	Tons zinc conc.	1,830	1,720
Pilbara	Tons copper ore	—	—
Poderosa	Tons copper ore	700	706
Rhodesia Broken Hill	Tons lead	1,981	1,844
Sulphide Corporation	Tons lead conc.	2,461	2,006
	Tons zinc conc.	4,114	3,150
Tanganyika	Tons copper	3,057	3,290
Transvaal Silver	Tons silver-lead bullion	365	362
Zinc Corporation	Tons zinc conc.	9,400	7,490
	Tons lead conc.	876	934

Imports of Ores, Metals, etc., into United Kingdom.

		Mar.	April.
Iron Ore	Tons	221,812	255,687
Manganese Ore	Tons	11,141	8,712
Iron and Steel	Tons	63,842	59,863
Copper and Iron Pyrites	Tons	33,575	30,492
Copper Ore, Matte, and Prec.	Tons	260	825
Copper Metal	Tons	5,619	3,906
Tin Concentrate	Tons	2,271	2,146
Tin Metal	Tons	2,911	2,473
Lead, Pig and Sheet	Tons	13,429	14,180
Zinc (Spelter)	Tons	6,031	3,966
Zinc Sheets, etc.	Tons	840	1,360
Quicksilver	Lb.	93,530	91,568
Zinc Oxide	Tons	455	396
White Lead	Cwt.	7,756	10,541
Barytes, ground	Cwt.	42,471	64,575
Asbestos	Tons	1,398	2,370
Phosphate of Lime	Tons	42,134	16,444
Mica	Tons	99	65
Sulphur	Tons	965	1,121
Nitrate of Soda	Cwt.	62,178	8,120
Petroleum: Crude	Gallons	18,825,520	9,919,740
Lamp Oil	Gallons	13,219,351	17,216,487
Motor Spirit	Gallons	27,494,464	26,702,668
Lubricating Oil	Gallons	5,537,906	8,238,537
Gas Oil	Gallons	5,372,704	4,573,785
Fuel Oil	Gallons	25,970,170	56,653,524
Asphalt and Bitumen	Tons	[illegible]	8,644
Paraffin Wax	Cwt.	65,519	99,456
Turpentine	Cwt.	[illegible]	[illegible]

Outputs of Tin Mining Companies.

In Tons of Concentrate.

	Feb.	Mar.	April.
	Tons	Tons	Tons
Nigeria:			
Bisichi	30	33	25
Ex-Lands	30	30	—
Filani	2	2½	2
Gold Coast Consolidated	—	—	—
Gurum River	8	9	9
Jos	10¾	11	8
Kaduna	20	22¾	15¾
Kaduna Prospectors	14¼	20⅛	9¼
Keffi Consolidated	20	20	20
Lower Bisichi	4	3¼	3½
Mongu	36¾	37¼	33½
Naraguta	55	55	40
Naraguta Extended	6	5	7
Nigerian Consolidated	10	11	8
N.N. Bauchi	45	40	36½
Rayfield	39	40	40
Ropp	81	126	143
Rukuba	4	4	4
South Bukeru	16	20	20
Tin Fields	—	8	—
Yarde Kerri	11	10	9½
Federated Malay States:			
Chenderiang	—	72*	—
Gopeng	54	65½	72
Idris Hydraulic	19½	19½	19¼
Ipoh	12¼	9½	19½
Kamunting	—	82*	—
Kinta	41¾	42¼	40
Lahat	26¾	21⅛	26¼
Malayan Tin	74½	78¾	77½
Pahang	230	233	234
Rambutan	18	18	19½
Sungei Besi	36	39	39
Tekka	39	42	42
Tekka-Taiping	28	30	30
Tronoh	25	76½	74
Other Countries:			
Aramayo Mines (Bolivia)	234	235	259
Berenguela (Bolivia)	29	32	38
Briseis (Tasmania)	—	—	—
Deebook Ronpibon (Siam)	29	29	21½
Leeuwpoort (Transvaal)	—	71*	—
Macreedy (Swaziland)	—	—	—
Renong (Siam)	62	77	85½
Rooiberg Minerals (Transvaal)	—	—	—
Siamese Tin (Siam)	86¾	103¾	93¼
Tongkah Harbour (Siam)	82	75	88
Zaaiplaats (Transvaal)	—	—	—

* Three months.

Nigerian Tin Production.

In long tons of concentrate of unspecified content.

Note.—These figures are taken from the monthly returns made by individual companies reporting in London, and probably represent 85% of the actual outputs.

	1917	1918	1919	1920	1921	1922
	Tons	Tons	Tons	Tons	Tons	Tons
January	667	678	613	547	438	473
February	646	668	623	477	270	412
March	655	707	606	505	445	456
April	555	584	546	467	394	434
May	509	525	483	383	337	—
June	473	492	484	435	423	—
July	479	545	481	484	494	—
August	551	571	616	447	477	—
September	[illegible]	520	561	528	595	—
October	578	491	625	626	546	—
November	621	472	536	544	564	—
December	655	518	511	577	555	—
Total	6,927	6,771	6,685	6,022	5,618	1,772

Production of Tin in Federated Malay States.

Estimated at 70% of Concentrate shipped to Smelters
Long Tons.

	1918	1919	1920	1921	1922
	Tons	Tons	Tons	Tons	Tons
January	3,030	3,765	4,265	3,298	3,143
February	3,197	2,734	3,014	3,111	2,572
March	2,609	2,819	2,770	2,190	2,839
April	3,308	2,858	2,606	2,692	2,896
May	3,332	3,407	2,741	2,884	—
June	3,070	2,877	2,940	2,752	—
July	3,373	3,756	2,824	2,734	—
August	3,259	2,956	2,786	3,051	—
September	3,157	3,161	2,734	2,338	—
October	2,870	3,221	2,837	3,161	—
November	3,132	2,972	2,573	2,800	—
December	3,022	2,409	2,838	3,435	—
	37,370	36,935	34,928	34,446	11,450

Stocks of Tin.

Reported by A. Strauss & Co. Long Tons.

	Mar. 31	Apr. 30	May 31
Straits and Australian Spot	1,439	1,351	999
Ditto, Landing and in Transit	340	175	560
Other Standard, Spot and Landing	4,990	5,627	5,804
Straits, Afloat	1,050	875	1,100
Australian, Afloat	90	75	60
Banca, in Holland	3,756	2,884	2,857
Ditto, Afloat	230	651	502
Billiton, Spot	95	83	72
Billiton, Afloat	—	—	—
Straits, Spot in Holland and Hamburg	—	—	—
Ditto, Afloat to Continent	525	740	630
Total Afloat for United States	5,437	6,052	7,730
Stock in America	3,086	2,721	1,921
Total	21,040	21,244	22,235

Shipments, Imports, Supply, and Consumption of Tin.

Reported by A. Strauss & Co. Long tons.

	Mar.	Apr.	May
Shipments from:			
Straits to U.K.	1,000	825	1,050
Straits to America	3,455	3,800	4,860
Straits to Continent	530	725	510
Straits to other places	325	175	175
Australia to U.K.	130	25	—
U.K. to America	745	414	125
Imports of Bolivian Tin into Europe	1,474	411	1,233
Supply:			
Straits	4,985	5,350	6,420
Australian	130	130	—
Billiton	10	—	—
Banca	265	1,560	1,835
Standard	706	890	616
Total	6,096	7,930	8,871
Consumption:			
U.K. Deliveries	2,659	2,009	2,047
Dutch ,,	251	75	274
American ,,	6,030	4,995	4,740
Straits, Banca & Billiton, Continental Ports, etc.	550	647	819
Total	9,490	7,726	7,880

Imports and Exports of Gold and Silver

During April, 1922.

		Imports.	Exports.
Gold:	Unrefined Bullion .... £	928,919	—
	Refined Bars .... ,,	349,327	1,097,116
	Coin .... ,,	—	240,977
Silver:	Unrefined Bullion ... oz.	59,397	—
	Refined Bars .... ,,	2,380,791	4,201,799
	Coin .... £	427,023	170,462

Outputs Reported by Oil-producing Companies.

In Tons.

	Feb.	Mar.	Apr.
Anglo-Egyptian	13,579	15,435	12,290
Anglo-Texas	2,131	2,187	1,892
Anglo-United	609	1,046	954
Apex Trinidad	3,340	6,600	4,450
British Burmah	9,100	10,751	10,285
Caltex	10,335	7,492	8,063
Dacia Romana	213	211	205
Indo-Burma	993	1,224	—
Kern River	15,153	16,516	16,712
Lobitos	8,181	9,123	8,691
Phœnix	928	3,927	2,289
Roumanian Consolidated	1,616	1,763	2,120
Santa Maria	1,671	1,814	2,021
Steaua Romana	15,600	18,300	17,570
Trinidad Leaseholds	8,400	9,050	8,500
United of Trinidad	3,486	3,469	4,170

Quotations of Oil Companies' Shares.

Denomination of Shares £1 unless otherwise noted.

	May 5, 1922 £	s.	d.	June 6, 1922 £	s.	d.
Anglo-American	4	16	3	5	5	0
Anglo-Egyptian B	1	16	3	1	15	0
Anglo-Persian 1st Pref.	1	5	0	1	5	0
Apex Trinidad	2	0	0	2	2	6
British Borneo (10s.)		12	6		12	6
British Burmah (8s.)		15	0		13	9
Burmah Oil	5	16	3	5	10	0
Caltex ($1)		2	6		2	6
Dacia Romano		15	0	1	3	9
Kern River, Cal. (10s.)	1	4	3	1	1	6
Lobitos, Peru	5	0	0	5	11	3
Mexican Eagle, Ord. ($5)	3	8	9	3	8	9
„ „ Pref. ($5)	3	6	3	3	5	0
North Caucasian (10s.)		13	9		12	6
Phœnix, Roumania	1	7	0	1	8	0
Roumanian Consolidated		14	6		17	0
Royal Dutch (100 gulden)	43	0	0	42	10	0
Scottish American		2	6		2	6
Shell Transport, Ord.	5	8	9	4	17	6
„ „ Pref. (£10)	9	15	0	9	12	6
Trinidad Central	2	15	0	2	2	6
Trinidad Leaseholds	1	6	3	1	3	0
United British of Trinidad		12	6		12	6
Ural Caspian		17	6		15	0
Uroz Oilfields (10s.)		12	6		12	0

Petroleum Products Prices. June 9.

Refined Petroleum: Water white, 1s. 2d. per gallon; standard white, 1s. 1d. per gallon; in barrels 3d. per gallon extra.

Motor Spirit: In bulk: Aviation spirit, 2s. 6d. per gallon; No. 1, 2s. 2d. per gallon; No. 2, 2s. per gallon.

Fuel Oil: Furnace fuel oil, £3 12s. 6d. per ton; Diesel oil, £5 per ton.

American Oils: Best Pennsylvania crude at wells, $3·50 per barrel. Refined standard white for export in bulk, 6 cents per U.S. gallon; in barrels 12 cents. Refined water white for export in bulk, 7 cents per U.S. gallon; in barrels 13 cents.

Dividends Declared by Mining Companies

During month ended April 10.

Company	Par Value of Shares	Amount of Dividend
Ouro Preto Gold	Ord. £1	7½% less tax.
	Pref. £1	7½% less tax.
Scottish Australian Mining	£1	10% less tax.
Gold Fields Rhodesian	10s.	6d. less tax.
St. John del Rey	Pref. £1	1s. tax paid.
	Ord. £1	2s. 3d. less tax.
Rhodesia Gold Mining and Investment	10s.	9d. less tax.
Lobitos Oil	£1	25% tax paid.
New Heriot	£1	1s. 6d.*
Glencairn Gold	£1	1s. 4d.*
Lake View Investment Trust	10s.	5% less tax.
Zinc Corporation	Pref. £1	2s. less tax.
Princess Estate	£1	1s. 2d.†
Oroville Dredging	£1	9d. less tax.
Shell Transport	£1	3s. 6d. tax paid.

* Final distribution of capital on liquidation.
† First distribution of capital on liquidation.

PRICES OF CHEMICALS. June 7.

These quotations are not absolute; they vary according to quantities required and contracts running.

		£	s.	d.
Acetic Acid, 40%	per cwt.	1	1	0
„ 80%	„	2	2	0
„ Glacial	per ton	65	0	0
Alum	„	14	0	0
Alumina, Sulphate	„	12	10	0
Ammonia, Anhydrous	per lb.		2	2
„ 0·880 solution	per ton	25	0	0
„ Carbonate	per lb.			4
„ Chloride, grey	per ton	35	0	0
„ „ pure	per cwt.	3	5	0
„ Nitrate	per ton	45	0	0
„ Phosphate	„	65	0	0
„ Sulphate	„	17	0	0
Antimony, Tartar Emetic	per lb.		1	6
„ Sulphide, Golden	„		1	3
Arsenic, White	per ton	39	0	0
Barium Carbonate	„	6	0	0
„ Chlorate	per lb.			7
„ Chloride	per ton	19	0	0
„ Sulphate	„	7	0	0
Benzol, 90%	per gal.		2	0
Bisulphide of Carbon	per ton	50	0	0
Bleaching Powder, 35% Cl.	„	14	0	0
„ Liquor, 7%	„	5	0	0
Borax	„	29	0	0
Boric Acid Crystals	„	60	0	0
Calcium Chloride	„	7	0	0
Carbolic Acid, crude 60%	per gal.		1	10
„ „ crystallized, 40°	per lb.			6
China Clay (at Runcorn)	per ton	4	10	0
Citric Acid	per lb.		2	4
Copper Sulphate	per ton	27	0	0
Cyanide of Sodium, 100%	per lb.			10½
Hydrofluoric Acid	„			7½
Iodine	per oz.		1	0
Iron, Nitrate	per ton	8	0	0
„ Sulphate	„	3	0	0
Lead, Acetate, white	„	41	0	0
„ Nitrate	„	46	0	0
„ Oxide, Litharge	„	36	0	0
„ White	„	41	0	0
Lime, Acetate, brown	„	8	10	0
„ „ grey 80%	„	13	10	0
Magnesite, Calcined	„	20	0	0
Magnesium, Chloride	„	9	0	0
„ Sulphate	„	9	0	0
Methylated Spirit 64° Industrial	per gal.		3	0
Nitric Acid, 80° Tw.	per ton	27	0	0
Oxalic Acid	per lb.			8
Phosphoric Acid	per ton	45	0	0
Potassium Bichromate	per lb.			6½
„ Carbonate	per ton	29	0	0
„ Chlorate	per lb.			5
„ Chloride 80%	per ton	12	0	0
„ Hydrate (Caustic) 90%	„	32	0	0
„ Nitrate	„	31	0	0
„ Permanganate	per lb.			10½
„ Prussiate, Yellow	„		1	3
„ „ Red	„		4	0
„ Sulphate, 90%	per ton	15	0	0
Sodium Acetate	per ton	24	0	0
„ Arsenate 45%	„	38	0	0
„ Bicarbonate	„	11	0	0
„ Bichromate	per lb.			6
„ Carbonate (Soda Ash)	per ton	15	0	0
„ „ (Crystals)	„	6	10	0
„ Chlorate	per lb.			3½
„ Hydrate, 76%	per ton	26	10	0
„ Hyposulphite	„	13	0	0
„ Nitrate, 96%	„	15	0	0
„ Phosphate	„	18	0	0
„ Prussiate	per lb.			11
„ Silicate	per ton	11	15	0
„ Sulphate (Salt-cake)	„	4	0	0
„ „ (Glauber's Salts)	„	4	0	0
„ Sulphide	„	22	0	0
„ Sulphite	„	12	10	0
Sulphur, Roll	„	10	10	0
„ Flowers	„	10	10	0
Sulphuric Acid, Fuming, 65°	„	24	0	0
„ „ free from Arsenic, 144°	„	4	10	0
Superphosphate of Lime, 30%	„	4	17	6
Tartaric Acid	per lb.		1	4
Turpentine	per cwt.	3	8	0
Tin Crystals	per lb.		1	3
Titanous Chloride	„		1	0
Zinc Chloride	per ton	22	10	0
Zinc Oxide	„	40	0	0
Zinc Sulphate	„	15	0	0

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD, SILVER, DIAMONDS:	June 6, 1921	June 6, 1922
	£ s. d.	£ s. d.
RAND:		
Brakpan	2 10 0	2 8 9
Central Mining (£8)	6 7 6	7 10 0
City & Suburban (£4)	3 0	2 6
City Deep	2 2 6	2 5 0
Consolidated Gold Fields	17 6	15 0
Consolidated Langlaagte	10 0	13 9
Consolidated Main Reef	10 0	11 3
Consolidated Mines Selection (10s.)	13 3	13 9
Crown Mines (10s.)	2 0 0	1 15 0
Daggafontein	3 6	3 0
Durban Roodepoort Deep	3 3	4 6
East Rand Proprietary	4 6	6 6
Ferreira Deep	7 6	7 6
Geduld	2 11 3	3 0 0
Geldenhuis Deep	4 6	6 0
Government Gold Mining Areas	4 0 0	4 6 3
Johannesburg Consolidated	1 3 0	1 5 0
Kleinfontein	5 6	6 3
Knight Central	4 0	4 6
Langlaagte Estate	11 6	16 0
Luipaards Vlei	1 6	3 3
Meyer & Charlton	4 0 0	3 13 9
Modderfontein, New (10s.)	3 5 0	3 13 9
Modderfontein B (5s.)	1 6 3	1 11 3
Modderfontein Deep (5s.)	2 5 0	2 3 9
Modderfontein East	11 3	8 6
New State Areas	1 2 6	1 12 6
Nourse	7 0	14 3
Rand Mines (5s.)	2 5 0	2 7 6
Rand Selection Corporation	2 15 0	2 17 6
Randfontein Central	8 6	11 0
Robinson (£5)	9 0	7 9
Robinson Deep A (1s.)	10 0	10 6
Rose Deep	13 0	12 6
Simmer & Jack	2 6	3 0
Springs	1 16 3	2 5 0
Sub-Nigel	12 6	12 6
Union Corporation (12s. 6d.)	15 6	17 3
Van Ryn	10 0	12 6
Van Ryn Deep	3 15 0	3 10 0
Village Deep	7 6	11 0
West Springs	12 6	11 3
Witwatersrand (Knight's)	13 9	13 9
Witwatersrand Deep	6 0	9 0
Wolhuter	4 3	3 3
OTHER TRANSVAAL GOLD MINES:		
Glynn's Lydenburg	6 6	16 3
Transvaal Gold Mining Estates	7 6	11 6
DIAMONDS IN SOUTH AFRICA:		
De Beers Deferred (£2 10s.)	10 5 0	12 10 0
Jagersfontein	2 5 0	3 0 0
Premier Deferred (2s. 6d.)	4 15 0	5 5 0
RHODESIA:		
Cam & Motor	10 0	11 3
Chartered British South Africa	12 0	12 6
Falcon	5 0	4 6
Gaika	8 6	11 6
Globe & Phœnix (5s.)	16 0	11 6
Lonely Reef	2 2 6	2 6 3
Rezende	3 0 0	2 10 0
Shamva	1 10 0	1 10 0
WEST AFRICA:		
Abbontiakoon (10s.)	2 9	2 0
Abosso	8 0	8 3
Ashanti (4s.)	12 0	14 6
Prestea Block A	1 6	1 6
Taquah	8 0	7 6
WEST AUSTRALIA:		
Associated Gold Mines	3 0	7 6
Associated Northern Blocks	2 6	2 9
Bullfinch (5s.)	1 0	1 0
Golden Horse-Shoe (£5)	11 3	10 0
Great Boulder Proprietary (2s.)	5 6	5 6
Great Fingall (10s.)	1 6	1 0
Hampton Celebration	4 0	3 6
Hampton Properties	5 0	4 6
Ivanhoe (£5)	15 0	16 3
Lake View Investment (10s.)	11 0	9 0
Lake View and Star (4s.)	1 6	2 3
Oroya Links (5s.)	1 0	1 3
Sons of Gwalia	5 0	3 0
South Kalgurli (10s.)	6 9	7 0

GOLD, SILVER, *cont.*	June 6, 1921	June 6, 1922
	£ s. d.	£ s. d.
NEW ZEALAND:		
Blackwater	2 6	5 0
Waihi	1 10 0	1 2 6
Waihi Grand Junction	8 6	7 6
AMERICA:		
Buena Tierra, Mexico	2 6	1 9
Camp Bird, Colorado	4 0	4 3
El Oro, Mexico	10 0	9 6
Esperanza, Mexico	17 6	14 6
Frontino & Bolivia, Colombia	10 0	7 6
Kirkland Lake, Ontario	15 0	17 0
Le Roi No. 2 (£5), British Columbia	2 6	2 6
Mexico Mines of El Oro, Mexico	4 15 0	3 12 6
Nechi (Pref. 10s.), Colombia	6 3	5 0
Oroville Dredging, Colombia	1 2 6	18 9
Plymouth Consolidated, California	12 6	7 6
St. John del Rey, Brazil	15 0	19 0
Santa Gertrudis, Mexico	5 6	8 0
Tomboy, Colorado	5 0	11 6
RUSSIA:		
Lena Goldfields	10 0	10 0
Orsk Priority	10 0	5 0
INDIA:		
Balaghat (10s.)	7 0	7 9
Champion Reef (2s. 6d.)	1 6	5 6
Mysore (10s.)	12 3	13 8
North Anantapur	2 6	2 6
Nundydroog (10s.)	5 6	9 0
Ooregum (10s.)	11 3	13 9
COPPER:		
Arizona Copper (5s.), Arizona	1 2 6	17 6
Cape Copper (£2), Cape and India	15 0	15 0
Esperanza, Spain	6 3	5 0
Hampden Cloncurry, Queensland	5 0	8 6
Mason & Barry, Portugal	1 15 0	2 7 6
Messina (5s.), Transvaal	4 0	3 0
Mount Elliott (£5), Queensland	12 6	12 6
Mount Lyell, Tasmania	12 6	17 3
Mount Morgan, Queensland	11 3	13 6
Namaqua (£2), Cape Province	15 0	1 15 0
Rio Tinto (£5), Spain	31 0 0	29 10 0
Russo-Asiatic Consd., Russia	11 6	8 3
Sissert, Russia	7 6	4 6
Spassky, Russia	13 9	8 9
Tanganyika, Congo and Rhodesia	1 5 0	17 6
LEAD-ZINC:		
BROKEN HILL:		
Amalgamated Zinc	16 3	15 0
British Broken Hill	17 6	1 3 9
Broken Hill Proprietary	1 17 6	1 6 3
Broken Hill Block 10 (£10)	10 0	7 6
Broken Hill North	1 5 0	1 11 3
Broken Hill South	1 5 0	1 11 3
Sulphide Corporation (15s.)	10 0	11 0
Zinc Corporation (10s.)	8 9	12 0
ASIA:		
Burma Corporation (10 rupees)	7 0	6 3
Russian Mining	7 6	5 6
RHODESIA:		
Rhodesia Broken Hill (5s.)	7 6	6 0
TIN:		
Aramayo Mines, Bolivia	2 5 0	2 7 6
Bisichi (10s.), Nigeria	4 6	5 9
Briseis, Tasmania	2 6	3 3
Chenderiang, Malay	13 0	11 3
Dolcoath, Cornwall	1 9	9
East Pool (5s.), Cornwall	3 6	2 3
Ex-Lands Nigeria (2s.), Nigeria	1 6	1 6
Geevor (10s.), Cornwall	2 6	3 0
Gopeng, Malay	1 11 3	1 16 3
Ipoh Dredging, Malay	11 3	8 9
Kamunting, Malay	1 7 6	15 3
Kinta, Malay	1 10 0	1 17 6
Lahat, Malay	1 5 6	6 3
Malayan Tin Dredging, Malay	1 8 9	1 3 9
Mongu (10s.), Nigeria	12 6	10 0
Naraguta, Nigeria	18 9	15 0
N. N. Bauchi, Nigeria (10s.)	3 0	2 0
Pahang Consolidated (5s.), Malay	6 6	5 6
Rayfield, Nigeria	4 0	2 3
Renong Dredging, Siam	1 12 6	1 1 3
Ropp (4s.), Nigeria	6 6	5 6
Siamese Tin, Siam	2 2 6	1 17 6
South Crofty (5s.), Cornwall	6 6	5 0
Tehidy Minerals, Cornwall	8 9	7 6
Tekka, Malay	17 6	17 6
Tekka-Taiping, Malay	1 0 0	18 9
Tronoh, Malay	1 5 0	1 7 6

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

In this section we give abstracts of important articles and papers appearing in technical journals and proceedings of societies, together with brief records of other articles and papers; also notices of new books and pamphlets, lists of patents on mining and metallurgical subjects, and abstracts of the yearly reports of mining companies.

THE TREATMENT OF SLIME TIN

At the meeting of the Cornish Institute of Engineers held on May 6, R. H. Smythe read a paper on the treatment of slime tin giving suggestions for a new method of treatment.

He began by drawing attention to two points which have bearing on the subject, firstly the action of flowing water and secondly the behaviour of mineral particles in relation to it. When water, whatever its depth, flows down an inclined plane it consists of two layers, an upper and a lower. The upper travels at a faster rate than the lower, its surface forms fairly regular waves or ripples, and it possesses greater buoyancy. The lower layer travels more slowly, so that the upper may be said to roll over it. It is less buoyant and its flow is more regular, but is affected by the nature of the surface over which it travels.

Mineral particles may be divided into two classes, those which naturally float in the upper layer, and those which by weight or surface peculiarity sink to the lower. To determine the behaviour of the tin particles the author constructed a special apparatus. This consisted of a slightly inclined glass stage, attached to a microscope in such a way that a shallow layer of water could flow beneath the lens. When water $\frac{1}{16}$ in. in depth containing fairly coarse tin was allowed to flow over this stage, and a light was arranged to shine directly upon the object, amber-coloured particles of tin could be observed coming to rest on the surface of the glass; but, when various grades of slime were tested in the same way it soon became evident that only the coarser particles of tin were settling, in company with iron and silica. By focussing on the surface of the moving water the finer tin particles came into view, and with a travelling microscope these minute pieces of tin could be traced, throughout the length of the stage, travelling in the upper layer of the water and seldom or never touching the glass.

It is well known that the smallest mineral particles, in common with a number of other minute bodies, show under the microscope very rapid dancing movements which are quite independent of water currents or variations of temperature or pressure. These so-called "Brownian movements" are responsible for keeping very finely divided particles in suspension, and any means which would overcome them would result in immediate precipitation. Salt modifies Brownian movements in ordinary muddy water, acids diminish it, caustic alkalies apparently increase it, but some other alkaline hydrates overcome it completely. Aluminium hydrate, which will be discussed more fully later, possesses this power in a remarkable degree, even to the extent of clearing vegetable dyes by precipitating the colour particles, for which purpose it is selected as a mordant in dyeing. Unfortunately there does not appear to be any chemical agent which will precipitate the tin from slime, without at the same time bringing down the bulk of the other ingredients; but there are possibilities for further research on this point.

From these experiments, added to general knowledge of slime tin, it may be assumed that loss of fine tin is mainly attributable to the fact that when passed over a frame it does not come to rest but travels the whole way in the top layer of water. If tin never touches the frame it matters nothing whether the surface be of wood, rubber, cement, or glass, as none of these come to close enough terms with it to grip it. Roughened surfaces, such as cement and ground glass, "put the brake on" the lower layer of water, and cause it to flow more slowly, but have apparently no influence on the upper layer, which carries the fine tin. Actually, from experiment, surface seems to have very little influence, providing it be clean. Slime tin, when once it comes to rest, has a very remarkable cling, and apparently the reason why so much is lost is because it is never given the opportunity of resting on the chosen surface.

It is fairly common knowledge that certain chemicals will clear slime, but the fact that the solid particles can be precipitated does not necessarily mean that all the tin content can be collected. The author describes a method of precipitation which does materially increase the recovery of tin. Lime added to slime causes precipitation, providing that certain soluble mineral salts are present, such as sulphate of iron. Lime water is a hydrate of calcium, and it reacts with the soluble iron salt to form a hydrate of iron, which is heavy and sinks, dragging down the other floating particle, with it, and clearing the slime. This methods however, has serious disadvantages, as the hydrate of iron is not soluble and, being of a jelly-like nature, it imprisons particles of tin and carries them off the frame into the waste. Alum and magnesium sulphate have some slight action in clearing slime in soft waters, but here again similar drawbacks arise. Either of these, used separately, results in an increased loss of tin, owing to entanglement.

Before it is possible to use any of these precipitation methods to advantage in tin-recovery, it is necessary to employ an agent which will break up the sunken precipitate into its separate particles without causing them to float once more. When alum or magnesium sulphate *plus* a hydrate such as lime or ammonium hydrate, or *plus* carbide of calcium which produces calcium hydrate when mixed with water, are added to slime, precipitation is extremely rapid. But, when slime thus treated is passed over frames, there is an increased loss of fine tin, as the hydrate of aluminium or of magnesium formed is gelatinous and carries away various particles in its embrace. To overcome this difficulty various chemical solvents were tried, and it was found that by first adding alum to the slime, then lime water, and finally rendering the mixture faintly acid with any mineral acid or with acetic acid, the slime was cleared almost immediately and the mineral particles all remained separate and distinct. The reason for this appears to be that the aluminium hydrate formed by the combination of lime and alum first entangles all the mineral particles and collects them into masses. The weak acid, being a solvent of aluminium hydrate, removes the gelatinous mass, but leaves a very fine film around each separate particle, which not only adds to the weight but insulates the smaller fragments and puts a stop to Brownian movements.

A preliminary trial of this process was made, and the results were so encouraging that it was decided to test it on an ordinary slime plant for a month and compare results with those obtained previously. The material treated was slime dug from the river-bed below Grenville. The whole came from one pit and averaged 20 lb. to the ton by chemical assay. The plant consisted of five round frames, fed by a common launder, which discharged their heads into a set of culverts. From these culverts the heads were automatically fed into two large tin-frames, which discharged into another set of culverts. The alum, lime, and acid were fed in this order into the launder supplying the five round frames. The alum and lime were mixed with ashes and placed in two wooden boxes with gauze partitions through which a slow stream of water trickled and discharged into the launder. The sulphuric acid was diluted and stored in a kieve, with a tap, which was turned on just far enough to keep the slime fairly acid to litmus paper. It was found necessary to add the alum first, as it thus picked up the lime before the latter could combine with the soluble iron compounds, and for this reason also it is advisable to keep the boxes containing the lime and the alum side by side so that the solutions meet before they become greatly diluted by the water.

The first point noticed after adding the chemicals was an altered appearance of the surfaces of the first five round frames. The even red coating formerly observed gave place to a darker layer at the circumference of the frame, with dark streaks radiating downward. This was apparently due to the more rapid removal of oxides of iron and light gangue, exposing the heavier portions as they adhered to the surface. After a week it was noticed that the culverts which received the heads from the five round frames contained considerably less material than usual, but an assay showed that the tin value had been increased by 50%. The two tin-frames fed from these culverts also presented a different appearance, as they showed at the circumference a wide periphery of yellow tin merging into black, with an entire absence of the red iron oxide which had previously been present. The culverts receiving the concentrate from these two tin-frames after a month held only 70% of their normal quantity of concentrate, but assay showed that it held nearly double the percentage of tin as compared with the previous month when the same material was treated. It was found only necessary to buddle this one before sending it to the smelter, whereas it had been necessary to carry out this process three times the previous month.

Unfortunately, owing to transport difficulties, it was not possible to maintain the supply of 20 lb. slime throughout the second month, and for one and a half weeks waste from the previous month averaging only 5 lb. to the ton was substituted. The recovery for the previous month when 20 lb. slime was used throughout without the addition of chemicals was 18 cwt., while for the second month when 20 lb. slime was used for two and a half weeks only and 5 lb. stuff for one and a half weeks, the recovery was 16 cwt., which shows an increased recovery of 25% as against the previous month.

Another point of interest was that, after commencing the chemical treatment, on only two occasions throughout the month could a trace of tin be found on vanning the waste from the first round frames, while beforehand a visible head of fine tin could be seen on every shovel.

The cost of treatment throughout the month worked out at a little under 1½d. a ton, but as in this case the materials were purchased through a dry house top prices were paid. If materials were purchased in ton lots from the manufacturers, the cost would work out at ½d. per ton of stuff treated, at present prices.

This treatment was applied to ordinary slime, without any previous classification, but the author emphasizes that classification of slime is quite as important as classification of coarse tin if the best results are to be obtained. Tin oxide in the process of pulverizing fractures into particles of varying sizes. Under the microscope some of these splinters may be measured and may not exceed 1,500 mm. in diameter. It is quite evident that such minute fragments, which taken altogether may form an appreciable proportion of the tin in any particular sample, cannot be collected on a frame if they are accompanied by other tin particles, one hundred times their size and weight, as a flow of water which would clean the coarser tin would wash away the fine, while a flow of water which would preserve the fine tin would not be sufficient to remove the heavy gangue. Moreover, even the finest tin slime contains tin particles which differ enormously in size, and if the best results are to be obtained in dressing it is just as necessary to classify the slime tin as it is to separate the fine tin from the coarse. There is no apparatus which will classify slime by size, as there is no mesh so fine as to allow these minute portions to escape while retaining those which are only a little less minute. When these finer particles do succeed in reaching the surface of a frame, if they ever do so, they are associated with particles of silica and iron which are sufficiently heavy to resist the action of the water, and so they become washed away and lost.

In classifying slime the lime and alum treatment is of the greatest service, when used in the following manner. The slime is allowed to flow through a series of settling tanks, arranged so that No. 1 overflows into No. 2, No. 2 into No. 3, and so on. From three to five tanks may be employed, as occasion warrants, in cascade method. Alum and lime, or preferably carbide of calcium, are added in fair quantity to the first tank. In this an agitator is arranged. The aluminium hydrate traps all the fine tin and waste in the upper levels of the first tank, and thus all those particles which are not sufficiently heavy to sink in the disturbed water are carried over into tank No. 2. Such portions as will sink do so, but those very light particles which the gentle inflow of water keep in suspension pass over into tank No. 3, and so on. The tank before the last is kept slightly acid by sulphuric acid to dissolve excess of aluminium hydrate, and so the bulk of the remaining solids settle in the last tank and either clear water or water containing the red oxide of iron passes over. The result is that No. 1 tank holds all the heavier tin and coarse gangue, which may be passed through a pulverizer or otherwise treated according to its size. No. 2 tank is usually very rich in finer tin, while the last tank holds the microscopic particles with correspondingly fine gangue.

The water which passes over contains practically all the mica, when present, and the iron oxide. Another important point is that concentration occurs naturally in these tanks through loss of these two latter ingredients. To demonstrate this, slime was passed through a series of five tanks and chemical assays were made of the contents after twelve hours' running. The original material passed into the first tank assayed 17·5 lb. to the ton, the material in the second, third, and fourth tanks assayed 27 lb. each, while that in the last was 22 lb. metallic tin per ton chemical assay.

The principle of classification of slime in tanks is as follows. The particles which flow from one tank into another, as from No. 2 into No. 3, are those which float at the same level in moving water, and it follows that they are all of approximately the same floating weight and there will be present no small particles of tin of lower floating weight than that of the gangue as they will float off into tank No. 3. The particles of gangue may be considerably greater in size than the particles of tin, but as each has now an equal gravity when suspended in water, it follows that with a level start down a tin-frame the particle which offers the greater surface to the stream of water will be propelled the faster. As, also, the lime and alum bring all the solids into the lower layer of water, and so on to the floor of the frame, the particles of tin being smaller will be left behind in the race. The author is also of opinion that even the finest tin when treated with this mixture has a greater affinity for wood than has the gangue. The material collected from each of these tanks can then be treated specially according to the size of the tin present. That from all but the last two tanks will require the addition of a little acid before it reaches the frame, while that from the last two will need no further treatment if passed over the frames at once. If slime thus treated is left for many days exposed to air, the aluminium hydrate becomes partly converted into oxide, and the effect is diminished. In this case more alum and lime will be needed when they come to the frames. The finer the tin the less rapid should be the flow of water, which if too fast might wash away the material from the last tank bodily.

THE PECHEY COPPER LEACHING PROCESS

Chemical Engineering and Mining Review (Melbourne) for March 5 contains a paper by J. D. Audley Smith on the hydro-metallurgy of copper, with special reference to the Pechey process at Whim Well and Mount Hope.

This process was first employed at the Girilambone copper mine, New South Wales, by G. A. Pechey, the inventor, and was applied to the treatment of several thousand tons of tailings, which had been previously partly leached by sulphuric acid. The cost of procuring sulphuric acid had been a serious item, and would have no doubt prohibited the extensive use of it as a leaching agent; therefore some other method had to be devised in order to obtain a solvent for the copper. The operations involved in the process are more or less simple. After preliminary preparations, the process consists of treatment with a dilute solution containing sulphate of iron ($FeSO_4$) which is distributed over the surface of heaps in wooden launders, and in such a manner that the washing can be conveniently done in sections. After the solution has percolated through the dump, it is collected in drains situated around the base, and conveyed to a common well or sump. From the well, an air-lift raises the liquors to the top of a tower filled with coke, where it is allowed to descend in the form of a spray against an ascending current of sulphur dioxide gas. This gas is generated in a sulphur burner, through which passes a stream of compressed air of low pressure just sufficient to maintain combustion and overcome the resistance of the tower. Latterly it has been the practice to use a deep vat in place of the tower. In this vat, generally 12 ft. deep by 10 ft. in diameter, are arranged perforated floors and stones, so as to break up the stream of sulphur dioxide gas into small bubbles as it is released at the bottom of the vat. This apparatus is known as the "converter," in view of its function of reducing ferric sulphate and forming the necessary solvent (sulphuric acid) for the process.

More or less ferric sulphate forms in the solutions during percolation through the heaps, as well as the copper sulphate which is dissolved, and this is reduced to ferrous sulphate and sulphuric acid by the sulphur dioxide gas as follows:—

$$Fe_2(SO_4)_3 + SO_2 + 2H_2O = 2FeSO_4 + 2H_2SO_4$$

It will be noticed that for every molecule of sulphur dioxide introduced into the reaction two molecules of sulphuric acid are formed and made available for dissolving copper from an oxidized ore. No claim is made for dissolving copper in the sulphide form, and this acid is only useful for dissolving minerals such as oxides, carbonates, and some forms of silicate, which latter are generally less soluble. The solutions at this stage, containing free sulphuric acid in a dilute form, are allowed to percolate through oxidized ore placed in vats. Here the acid is nearly neutralized, and forms sulphates of copper, iron, and alumina. After being passed through two, or better, three vats of ore arranged in series, the solution is then ready for precipitation by metallic iron.

The precipitating system consists of a series of round wooden vats connected together, so that the solution passes through all of them. These vats are filled with light scrap iron, which is supported by wooden grids a short distance above the bottom, so that the precipitate of metallic copper formed can be settled apart from the iron and finally drawn for drying and bagging as required. This form of precipitate vat is a great improvement over the old Spanish canals, and the later trough systems, and less labour is required in cleaning up the copper precipitate.

At Mount Hope, N.S.W., it has been the practice to treat one or two of the precipitation vats of the series with the exhaust steam coming from the air-compressor. This heat materially assists the precipitation of the copper. Without the aid of heat a much longer system of precipitation vats would be necessary, and there is an added advantage also in having the greater proportion of the precipitate formed in the head vat of the series, where it can be frequently recovered, thus reducing the number of vats which would otherwise have to be attended to. The tail solutions from the vats are then finally conveyed to the tops of the dumps, and used again for washing as described above. The passage of the solutions is thus a cycle.

While there are many details of importance which have to be learned by experience, the *modus operandi* is quite simple. None of the chemical reactions is new to science, and although it was known at Rio Tinto generations ago that ferric sulphate was present in the heap solutions, no one apparently thought of reducing it in this manner with the object of producing sulphuric acid for use in leaching oxidized copper ore.

The writer was metallurgical chemist to the Arizona Copper Co., Ltd., in 1893, and helped to introduce the first successful copper leaching plant in the western states of America. There, in order to provide a solvent for the copper, it was necessary to erect a sulphuric acid plant which cost more than half the capital outlay contemplated. A process making it unnecessary to build such a plant would then have been of the greatest value.

It has been demonstrated at Girilambone, Mount Hope, and Whim Well that the sulphuric acid solvent can be produced commercially by this process, and it is only necessary to make the operations sufficiently extensive by providing large dumps or heaps to ensure commercial results. The question of cost is all-important, of course. The work at Girilambone consisted in the treatment of 23,000 tons of tailing and 3,696 tons of slime. The tailing had previously been partly leached by sulphuric acid, and assayed 0·9% copper before treatment by the Pechey process. The assay of the slimes was 1·7% copper present as carbonate and oxide. As regards production of copper, the operations were therefore limited to 6½ tons of copper per month, and the costs were therefore excessive. The work was completed in January, 1911, and the total cost of production, including realization, was £37 14s. per ton of copper produced. No head office expenses were included. The total recovery from the tailing and slime was 108 tons copper (equal to 40% extraction of the copper), and the treatment was no doubt reaching the unprofitable stage, due to diminishing output and the small-scale operations.

In 1913 Mr. Pechey commenced operations at Mount Hope on several heaps of jig tailings, aggregating 28,000 tons, and assaying 3% copper. One heap of 12,000 tons was entirely oxidized, the bulk of the copper contents existing as carbonate, with not more than 10% in the form of copper glance. A second heap was largely carbonate ore, but contained sulphides (chalcopyrite) around the fringe. A smaller heap consisted of mixed minerals and sulphides.

In March, 1913, the writer was at Mount Hope and examined the ore dumps with Mr. Pechey before any treatment was commenced. Apparently there had been no sulphating of the chalcopyrite except in the cases where there was a coating of black secondary ore. A small accumulated dump of slime, however, had been left which was strongly sulphated, indicating the previous existence of black, friable ore. There was enough sulphate found, however, in one of the large heaps of jig tailings to make it possible to start leaching with water. No sulphuric acid was required for starting, and all the copper produced from these heaps was dissolved by acid made in the process. The heap of oxidized ore was leached in vats, and the tailing added to the main residue, where there are now two large dumps alongside one another. Early in 1914 the mine was taken over by Mount Hope, Ltd., and the leaching continued until July of the same year, when water supplies ran out, and a severe drought reigned for more than a year. Several similar stoppages for the same reason have occurred. In 1917 milling operations were commenced, and nearly 11,000 tons of jig tailing was added to the main dump. After 1918 heap leaching became unprofitable by itself, as the copper was being exhausted, thus affecting the rate of production. However, operations were continued in conjunction with other work, with several stoppages when water became scarce, until September, 1920. During 1913 the monthly output of copper as precipitate was almost 15 tons per month, the cost of production and realization being £42 per ton of copper. The cost gradually rose to £56 by the middle of 1915, owing to the drop in production to 8·9 tons per month. In 1919 the cost had risen to £61, and £74 in December of that year, owing to a fall in the output to 6 tons per month, and the prices for labour and supplies increasing. The above costs do not include head office expenditure, which would have averaged £7 per ton of copper. The production of copper from these jig residues totalled 565 tons of copper, and it will pay to recover copper intermittently from this source in conjunction with other work. The cost of realization in 1913 was equal to £10 per ton of copper, and in 1919 £20.

It naturally follows as the result of considering the above data that the heaps should be as extensive as possible and kept supplied with fresh ore from the mine or milling plant, and the production maintained as a constant or increasing quantity. In this manner the costs can be kept at a sufficiently remunerative level, provided there are no increases in wages and supplies.

During 1918 the writer, in the capacity of a consultant, undertook an experimental campaign in the treatment of Whim Well ore. This preliminary work was followed in 1919 by experimental dump leaching, with a view to ascertaining the commercial value of the process in that instance. After some initial difficulties, and shortage of water owing to a failure in the supply from the mine and a long drought, the plant was got into good working order, and commenced producing precipitate. Sufficient water was not available for normal circulation, which should have been at the rate of 120,000 gallons of solution per diem. As a result of the experimental work, which produced over 40 tons of copper, the West Australian Government has had an independent examination made by their State Mining Engineer's department, and have now made provision for a pumping plant to be erected, which, when completed, will furnish the mine with all the water that is required for leaching and domestic purposes. The water will have to be pumped from Balla, on the coast, a distance of ten miles to the mine, and the installation will cost at least £20,000.

At Whim Well there is a very large amount of ore available, which can be open-cut and added to the 70,000 tons of heap material now at the surface, assaying 4% copper. The dumps were not prepared in any way for leaching, and consist of different-sized material, more or less coarse, but it is expected that, owing to the nature of the ore (kaolinized slates), which is veined with oxidized minerals, the disintegration of the coarse material and recovery of the copper will be satisfactory.

The matter of recovery is all important. At Mount Hope the recovery has been well over 50%, but no exact sampling of the dump had been made when the writer was last at the mine. Samples taken from the older portion averaged well under 1%. With large scale operations, it is evident that, while extending the heaps with fresh ore, it will be possible to leach profitably the older and partly leached sections until but a small percentage of copper is left. Probably very poor sections would be given only two washings annually, and finally only one, thus providing the necessary time for the formation and accumulation of soluble copper.

There are a number of important points to be considered in a heap leaching process. In the early days of Rio Tinto it was considered necessary to build the heaps on impervious bottoms of tamped clay, and to provide shafts and chimneys for the proper ventilation and aeration of the mass. At the present time almost any soil is considered satisfactory. The writer's experience in America and Australia would influence him to the consideration of a tamped clay bottom, or if cheap clay were not available, then possibly a thin concrete bottom. In the case of a heap, the average height of which is 22 ft., the weight to be supported would be very little more than one ton per sq. ft. of area.

The slope is important, particularly if the ground is at all pervious. At Rio Tinto the minimum grade would be 2°, but it is always advisable to take advantage of a steeper slope, provided the ground is suitable.

There must be a sufficient water supply to maintain the circulation of solution at the proper rate. A dump perfectly dry will absorb in the first washing approximately 40 gallons per ton of ore. This factor will vary with the size of the material, and the character of the ore matrix. There is a distinct economy to be effected in the dry summer weather by confining the washes to adjacent sections.

The consumption of water varies greatly in summer and winter. By consumption is meant the loss by evaporation and re-absorption after the first wash, because some of the water absorbed in the first wash will have to be replaced in the second wash, say, six months later. For a dump of 30,000 tons and during a summer drought, the writer has known of as much as 15,000 gallons new water being supplied daily, while in the winter time the quantity to be replaced would be as low as 4,000 gallons. During wet weather the requirements may drop to nil, and there may even be an excess of water draining into the sumps. For an average figure 8,000 gallons can be taken, but it will be readily understood that close supervision in this matter is all important.

Mr. Blatchford, in his brief description of the leaching at Whim Well, mentions the use of the pyrite filter. This is not an adjunct of the Pechey process, but was introduced by H. R. Sleeman, the general manager, who has recently applied for patent right to cover the use of acid for leaching purposes formed in the reduction of ferric sulphate by iron pyrite. This is an old reaction which was known at Rio Tinto, and has been used by Joseph Irving at Bisbee, Arizona, for reducing copper liquors containing ferric sulphate before precipitation. Sulphides, if present in the heap, will oxidize and gradually form sulphates, and the amount of sulphur which will have to be burned daily in order to maintain the solution at its normal strength will vary with the quantity which is being made available by that oxidizing in the dump. This is a matter which requires careful regulation by the metallurgist in charge. At Mount Hope, during 1920, the main oxidized ore dump had been in course of treatment intermittently for several years, and had become so thoroughly sulphated by the oxidization of sulphides and saturated with sulphates, that a very small proportion of the normal consumption of sulphur was necessary during several months.

Little is known as to what happens chemically in the heap. At Rio Tinto, the earlier metallurgists sought to regulate the heat formed through chemical action by controlling the aeration. This is not now considered necessary since the temperature is readily reduced by washing. The main dump at Mount Hope in October, 1915, had a temperature of 120° F., as observed in three shafts, which were sunk between 12 and 15 ft. deep.

The chemical reactions of the heap are the product of time (several months). After the draining of the excess solution, ferrous sulphate in contact with entrained air forms normal as well as basic ferric sulphates. These slowly eat their way into the copper minerals, converting them into sulphates. When the time arrives for the following wash, there is therefore a certain proportion of the copper ready to be dissolved. At the same time, some normal ferric sulphate finds its way into the solution, which itself is largely ferrous sulphate. This ferric sulphate then is reduced by sulphur dioxide gas in the converter to acid, which is available for vat leaching. The reactions are therefore cyclical.

The composition of the solutions vary only slightly, and no foul solutions are accumulated. The heap is the regulator and purifier, precipitating the excess of iron, and other impurities of the solution which have been accumulated from the water, the scrap iron used in the process, and the ore itself. The large dumps at Mount Hope, originally almost chalky white, have become coloured a dark brownish-red tint.

To those who are familiar with copper leaching, the complexity of the basic sulphates of iron is well known. At Mount Hope the water contains considerable magnesium and sodium chlorides, which play an important part in the chemical reactions and finally become fixed in the heap. An analysis of these final residues will present an interesting problem.

That this heap-leaching process can be profitably employed has been proved. It is necessary, however, to make sure that the right conditions exist, and that the ore is suitable. There must be sufficient water available, the nature of the ground and the slope must be favourable, and the operations must be carried out on a sufficiently large scale to ensure economic working. With the gradual removal of copper from a heap the annual production decreases, and the costs increase in arithmetical ratio. It is necessary, therefore, to fix the production which is to be regularly forthcoming, and so conduct the mining operations and the creation of new heaps. It is also necessary that sufficient copper is being regularly added to the heaps to maintain the output. There are undoubtedly deposits in Australia for which this treatment is eminently suitable. The writer's experience inclines him to the belief that for successful heap leaching, a dry and arid climate is necessary. The ideal climate would seem to be one where there are dry, hot periods followed by wet ones. During a dry period the sulphating action is more noticeable than it is at any other.

A STOPING METHOD FOR THE FAR EAST RAND

In the *South African Mining and Engineering Journal* for April 1, R. E. Sawyer describes a suggested improved method of stoping flat ore-bodies such as are characteristic of the Far East Rand.

Some time ago the author, having been called on to lay out the stoping for a new mine, visited most of the mines on the Far East Rand to ascertain the current practice. The most notable feature was the difference in practice and system, and the lack of any definitely satisfactory method. The old standard method of stoping parallel with the winze and running out tracks every 30 ft. is most unsatisfactory and accounts largely for the low efficiency of the mines where it is practised. The foot-wall cross-cut system is much better, but it is at present only applied where large blocks of known value are available. The new lay-out here on the inside of the curve or centre rollers to keep the rope in position. The cars will certainly travel round the curve, but the wear and tear on guard rails, wheels, and ropes is very heavy and requires a small army of truck-busters, fitters, riggers, and timbermen for upkeep. The initial cost of installing one of these curves is well over £100. In a stope of 600 ft. backs at least 37 curves are required, and switches are butt to butt, there being only 15 ft. between frogs. Each track only serves 30 ft. of stope face, and has to be constantly advanced in short lengths to keep near the face. The stope is opened out by taking a strip, say 40 ft. wide, off each side of the winze, and the faces are then pushed outwards, travelling parallel with the winze, until the limits of the blocks are reached. Assuming the block extends 500 ft. on the strike on each side of the winze, by the time the block is completed it will

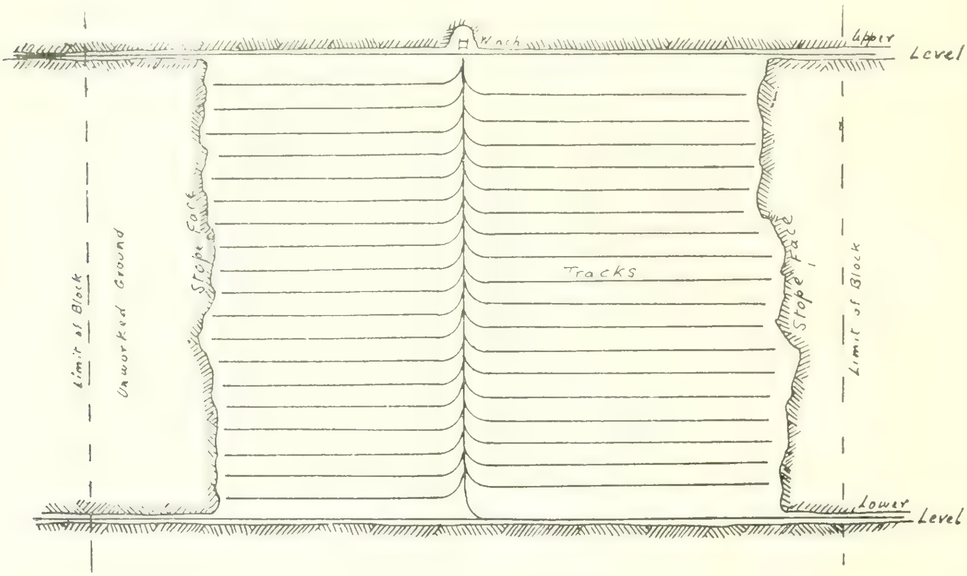


Fig. 1.—The Old Method.

described applies equally to the foot-wall cross-cut system in so far as the shape of the stope face is concerned, which is its main feature. In the author's opinion, the combination of this lay-out with the foot-wall cross-cut makes the latter system preferable in all cases where 50% of the block is worth stoping at all, especially if the values are in the lower half of the block.

The author first describes the old standard lay-out (Fig 1), and takes a block 1,000 ft. by 600 ft. A winze is put down connecting the two levels, which are approximately 600 ft. apart. Six inches or so of shale are carried below the contact. The winze is near the centre of the block, and is usually put down on the true dip, but occasionally it is as much as 45° away from this. Where it is on the true dip the angle to be turned through by the track coming from the winze into the stope is slightly under 90°. This is usually done by a curve of 20 to 30 ft. radius. To pull cars round this curve with a winch rope requires heavy guard rails on both sides of the inner rail and posts every 6 ft. be equipped with 19,000 ft. of 30 lb. track, 2 ft. 6 in. gauge, costing in rails alone approximately £4,720 ; 37 switches, costing £440 ; and 37 curves at £100 each ; making a total of £8,860 for track only. In the case of a winze not on the true dip, the curves going off on one side are easier, while those on the other side are much worse, if not impossible. This can be overcome by crossing over the winze from the acute-angle side and handling the rock from both tracks on the one switch. This method was suggested by H. Stuart Martin, and is embodied in the new standard. Two other grave objections to the old system must be considered, in connexion with support and ventilation respectively.

As regards support of workings, during the life of the block the whole of the tracks have to be kept clear and an attempt made to keep up the hanging wall over the entire area. As larger areas get stoped out this is found to be impossible, as the hanging wall will settle whatever method of support is adopted, and where the stope width is narrow the hanging has to be cut away to allow the trucks to pass, thus breaking the hanging and making matters worse. This difficulty will become more and more evident in the future.

As regards ventilation, with so many tramming ways that have to be kept open, it is impossible to confine the air current to the face of the stope where it is required. The Government Mining Engineer has already called attention to this, and it is a factor that, by itself, is sufficient to condemn the old method. The air current must be confined to a comparatively small area, as once it is diffused throughout the whole stope it is impossible to maintain any velocity and the air remains relatively unchanged from shift to shift, accumulating gas and dust to a dangerous extent.

The author proceeds to describe his new method (Fig. 2). The winze is put down at a small angle, say 20° to 25°, with the true dip. At least 2 ft. of shale must be carried below the contact, where the stope first three slices, that is, 100 ft. up the stope, the rock, approximately 40,000 tons, is handled down to the lower level by means of diagonal tracks, connecting the stope tracks in a very economical way, no power being required. It is possible to lower all rock to the bottom level, but this entails keeping the main winze open for the life of the block, frequently a costly business. The whole secret of putting in a correct pull-out from the stope to the main track is to have the curved part on the flat where the tramming is by hand, and to have a straight pull-out to the switch for the winch rope. This can only be done where the main track is well down in the shale, 2 ft. at least, and where the angle of the stope track to winze is more than 100°. If these conditions are fulfilled, guard rails, side timbers, and centre rollers are then unnecessary. On the one mine where this is realized and practised it is stated that guard rails are only an excuse for bad

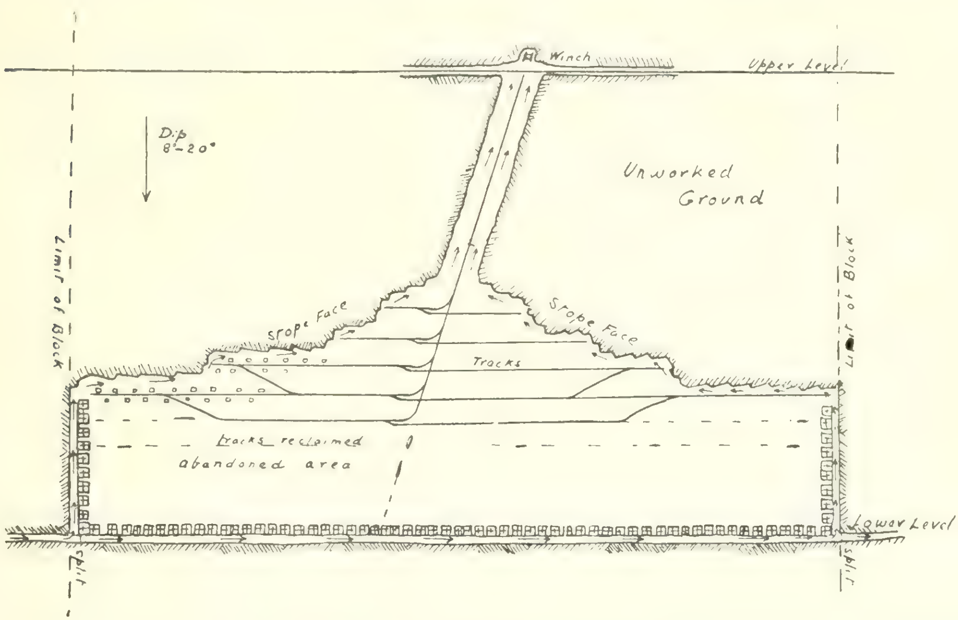


FIG. 2.—THE AUTHOR'S METHOD.

width is less than 5 ft. This is important, as it greatly facilitates the lay-out of the curves for stope tracks. The stope is opened out: (1) by taking off a strip 25ft. wide on either side of the winze by hammers to avoid smashing up the track and to economize by making use of the hammer boys who are under agreement to lash for two hours daily, to load direct into the main track from a distance of up to 25 to 30 ft. (2) By taking off a 40 ft. strip above the bottom drive and laying a track in the stope 30 ft. above the drive track. The switch to the winze track is taken off on the obtuse angle side. The track from the other side crosses over the winze track by means of a short length of rail which is easily removed by one boy, and joins the other track by an ordinary switch on the flat. As soon as the stripping above the drive has advanced, say, 100 ft., another strip 30 ft. wide is started off on either side of the winze, and so on; the stope faces then advance in echelon, that is, diagonally across the block, switches being taken off every 30 ft. to one side only. In practice it is found that for the track-laying. It is generally found that the first two or three strips advance quicker than the later ones, as it is easier to strip off the drive than to open out from the winze; consequently more rock has to be handled on these two or three tracks. To do this they are connected by short inclined stretches of track, down which full cars are spragged, the lower track serving as a return way for the upper. This greatly facilitates tramming. As soon as the bottom tracks have worked out to the end of the block and no longer serve as return tracks, they are pulled up and used farther up the stope, so that no more than five or six switches to the main track are in use at one time. By thus concentrating tramming, more efficient supervision is possible and a great deal of unnecessary running up and down the stope is avoided. Instead of the cars having to run over anything up to 38 switches, with consequent chances of derailment, only four switches are crossed in the new method. Sidings or loops are put in, where necessary, on the flat to facilitate tramming. In the event of a track being blasted, work is concentrated on other tracks until it is repaired. Before removing a track all the foot-wall in its vicinity is brushed and washed down to recover fines. That portion of the stope is now abandoned and the hanging wall is allowed to settle down on to the packs to any extent without interfering with the current work of the stope. It is evident that by advancing the faces in echelon much better benches can be carried than in a straight up-and-down face. The air and water pipe lines are shortened and simplified under this system. Each track serves approximately 100 ft. parallel to itself and 30 ft. at right angles, instead of only 30 ft. at its extreme end, as in the old method. It has been suggested that the track parallel with the face would be constantly blasted. This is not the case if the track is properly put in, that is, the top rail should be at least 3 in. below the foot-wall. The waste packer keeps a few hammer boys who put in pop holes in the shale in advance of the track, so that the tracklayer has no trouble in getting his track well down. In addition to this, the trammer always leaves a few carloads of rock above the track as an additional protection from blasting. The cost of track by this method is less than one-seventh of the old. Thus 3,000 ft. of track cost £750 ; ten switches, £120 ; five curves at £10 each ; total £920, as against £8,860, or a saving of nearly 10s. per fathom over the block. There is small chance of any of the track being unrecoverable, while by the old method long lengths are often lost under fallen hanging.

The author discusses ventilation and support under the new method. These are dealt with together, as the systematic support is such as to help ventilation. As soon as the bottom of the stope is far enough away from the lower level a row of "Maltese cross" packs are put in—that is, a 20 ft. square pack—the corners being made of pigstyes and the rest filled with stonewalling. These are put in 10 ft. apart and the space left is stone-walled on the side above the drive. To make a tight job the whole face of the packs can be sprayed with a cement gun. This row of packs is also necessary to keep the level open, as the hanging wall will probably come down in the abandoned area above. The same method is followed up the sides of the block, keeping the airways open. The saving in timber and stonewalling is very great, as no attempt should be made to support permanently the main worked-out area, only sufficient pigstyes being put in to render the workings safe. Extra pressure is undoubtedly felt at the face, but this gives increase in breaking efficiency.

This system is really a modified long-wall, and has all its advantages, the principal being to work homewards and let the roof behind look after itself. The support of the hanging wall on the Far East Rand will call for more attention as time goes on. Sand-filling may be ruled out as impracticable on flat reefs. Although in many cases the reef is narrow, at least 48 in. stope width must be carried to allow of blasting and tramming facilities. Sorting in stopes is and can only be done to a limited extent. The system described lends itself admirably to a scheme whereby all waste rock that is not sorted in the stope is sorted out at a central station underground. It could then be re-loaded into empty trucks returning to stopes and packed systematically. The waste rock would be delivered to those stopes, which, owing to a big reef width, have no packing material available. This, however, would entail the use of a specially low side-tipping truck. By putting three machines on each side an efficiency of 2·6 fathoms per machine-shift can easily be obtained, owing to (1) facility for cleaning out rock ; (2) increased breaking efficiency ; (3) safer working and less stoppage owing to falls of rock on tramming ways ; and (4) better benches. At this rate the block will be finished in under 32 months, the last period being as safe as the first. Under the old method, with the low efficiency of under one fathom per machine-shift, which obtains on some of the mines where it is practised, the block will last over eight years. The state of the hanging wall during the later years over the centre area of the stope which still has to be kept up can be better imagined than described.

The adaptation of this method to the foot-wall cross-cut is simplicity itself. The tracks are put in 30 ft. apart, and each box-hole serves three tracks. No switches or curves are necessary. A low side-tipping car running on light rails of narrow gauge is used. The objection to the foot-wall cross-cut that it was difficult to keep up the hanging wall over the box-holes for a long period, and that the loss of a box-hole was a very serious matter, is by this method largely overcome, as only two box-holes are in use at a time, the lower box-holes being abandoned as that portion of the stope is worked out.

The main advantages claimed for the new system are : (1) Great saving in tracks and pipes ; (2) less cost of installation and upkeep ; (3) more efficient tramming ; (4) safer working and low cost of supporting hanging wall ; (5) higher machinery efficiency ; and (6) systematic ventilation of the face is made easy. The author claims no single item as new or original, but hopes that this combination of methods will help to lower costs on some mines considerably.

THE OIL-SHALE OF ESTHONIA

At the meeting of the Institution of Petroleum Technologists held on May 9, E. H. Cunningham Craig read a paper on the oil-shale of Esthonia. This oil-shale has been called "kukkersite," from the name of the place where it was first exploited, but as it possesses all the usual characteristics of other oil-shales there is no need for the use of this specific term. The oil-shale is notable for its richness and for its occurrence in palæozoic rocks, namely the Lower Silurian. When speaking of its richness, it is to be remembered that the author does not include the richer torbanites among oil-shales. The oil-shale is found interbedded with limestone and overlain by it, and the seams vary in extent and thickness, attaining a thickness of 8 ft. at various places. The geological structure of the region is of the simplest, and the beds are as flat as when they were deposited on the ancient coast. The strata have been so little disturbed that their characteristics have hardly been altered, and they resemble Tertiaries.

The shale is a fine-grained deposit varying from a warm grey to an olive green in colour when fresh, but weathering to a bright reddish brown. It has a sandy appearance and fracture, which is quite illusory, as microscopic examination shows that there is not a grain of sand in it. It is crowded with fossil remains, chiefly in small fragments, but on bedding planes several species may be recognized, chiefly trilobites and brachiopods. The fauna is sufficient to enable the horizon to be identified with accuracy. Under the microscope the matrix appears to be very homogeneous and very finely granular, and all fully and evenly impregnated with a bright yellow kerogen. The fragments of fossils are not impregnated. As compared with other oil-shales, the fresh yellow colour of the impregnation is remarkable in so old a rock. It is much fresher and apparently less inspissated than the brown kerogen of the Scottish shales or the brilliant burnt-sienna-coloured kerogen of the New Brunswick shales. In fact, the bright colour is most nearly paralleled by that of the richest shales of Colorado. It is no doubt the undisturbed state of the strata and their being enclosed in fine-grained limestones that has enabled this kerogen to retain its freshness for such an enormous interval of time. Chemical analyses of the inorganic contents of the shale show great variations, due almost entirely to the varying quantities of carbonate of lime (fossil fragments) contained. From a series of analyses made in the Central Laboratory of the Esthonian Republic, the composition of the mineral matter is given as follows: Silica, 32·74%; alumina, 15·76%; iron oxide, 1·6%; lime (or calcite), 49·64%. This is a very high percentage of lime, almost all of which may be put down as fossil debris. It is obvious from these facts that, eliminating the lime as extraneous, the matrix has the composition of a fuller's earth, the most absorbent of argillaceous deposits.

Many analyses of the shale have been made to determine the percentages of volatile matter, ash, etc., but they show extraordinary variations. This is probably chiefly due to the methods that have been employed and the temperatures to which the material has been subjected. The volatile percentage has been given by different chemists as anything between 52·5 and 65%, while coke or fixed carbon is stated at from 5 to 11%. The reason for these differences is that if quickly subjected to a high temperature destructive distillation takes place with the deposit of free carbon; later at a higher temperature the free carbon, finely divided and closely associated with lime carbonate, reacts with it, giving off carbon monoxide and thus increasing the volatile percentage, which, of course, also includes the moisture present. A very careful distillation with gradually rising temperature will give different results, and probably a greater yield of oil, but less gas. From all the data available it seems that the average volatile percentage may be taken at from 54 to 56%, which is extraordinarily high for a shale. With such a high percentage of volatile matter is it obvious that the yield of oil per ton will be high. Theoretically over 90 gallons is possible, and has been attained occasionally in small-scale tests; but in works practice such a result is hardly possible, since deposit of carbon and formation of uncondensible gas cannot be prevented with such a highly inspissated kerogen.

The author proceeds to discuss various theories of the origin of these oil-shales. He inclines to the theory that their organic contents were formed by impregnation with inspissated petroleum coming from elsewhere, and indicates a source of such petroleum. At a comparatively short distance beneath the bands of shale are found thick beds of Cambrian sandstone. They are typical oilsands, and the Dictyonema shale associated with these sandstones is impregnated to capacity, some 10%. The Dictyonema shale is not an absorbent or colloidal shale, but it contains dark brown and highly-inspissated kerogen, as shown by microscopic examinations. Even the limestone, which is not by any means adapted for the absorption of inspissated petroleum, contains a slight impregnation, which reaches 8 to 10% in the thin beds associated with the shale. This, however, is not such direct evidence as could be wished, and it is necessary to make a wide and comprehensive study of the country to obtain confirmation of the suggested source of the impregnation of the shale. With such simple geological conditions there are no structures capable of concentrating petroleum towards definite localities, and therefore it is not possible to select any one district to test for the presence of residues of oil. The surface of the plateau also is so much covered by superficial deposits that solid evidence is only available here and there. Nevertheless, a certain amount of evidence has already been brought to light, and probably much more will be available later. At Kokskar, a small island some seven miles northeast of Reval, in a shallow boring which penetrated into the sandstone and conglomerate immediately overlying the Archæan granite gas was struck in appreciable quantity. At Kaali, near the centre of the Island of Oesel, there is a large mud-volcano in Lower Silurian strata. It is 200 metres in diameter, while the crater is 30 metres across and contains salt water, through which the gas bubbles. At. Keinis, in the island of Dago, a bore-hole 40 ft. deep struck water and a little oil. Finally, in a limestone quarry near Wanamoisa, where the stone is quarried for the cement works at Port Kunda, thin vertical veins of manjak are found. This is to the best of the writer's knowledge the oldest manjak in the world, and should be consequently highly inspissated. Extraction tests with carbon disulphide and with chloroform show that the material is entirely soluble in these liquids, that is to say, the material is 100% bitumen. This compares with 93 to 99% in Barbados manjak or gilsonite, and 2 to 12% in albertite. This is a most remarkable result, seeing that the kerogen of the shale is so highly inspissated. Possibly the intrusion of these manjak veins took place at a later period than the impregnation of the shale. Probably other similar occurrences will be discovered when more ground is opened up. The interesting point is that these veins occur actually slightly above the horizon of the oil-shale, proving that intrusion of liquid or semi-liquid petroleum from below has been extended at least as far as the absorbent fuller's earth, which has become an oil-shale. The evidence is therefore complete; there is all the evidence of a former oilfield, except favourable structure to concentrate petroleum. There are the oilsands, the shales, and even limestone bands impregnated according to their capacity, shows of gas—including a mud-volcano—a show of oil, and manjak veins. A simpler case can, in the writer's opinion, hardly be imagined, and no other explanation of the origin of the oil-shale will accord with the facts.

The writer also deals with the commercial development of these oil-shales. The shale has been proved in workable thickness at intervals for a distance of 36 miles from east to west, and 7 miles from north to south, but to make any estimate of the tonnage available would perhaps be premature. In one locality a tonnage of over five million per square mile is assured, but this is perhaps too much to expect over a large area. But three million tons per square mile has been proved over a fairly large area, and 2 or 2½ million may be taken as a very conservative estimate. An Esthonian geologist has estimated the total available tonnage at over 3,000 million, but the writer, taking account of the variations in thickness to which such fuller's earth deposits are liable, is not prepared at present to estimate the shale in sight at more than 1,000 million tons, though recognizing that further excavations may prove a very much larger quantity. For many miles, in fact all along the outcrop and for some miles southward the shale can be worked by open-cut. A steam navvy is used to remove the superficial deposit of sand, from 3 to 6 ft. in thickness, and then the shale is quarried by hand labour, the limestone bands picked out, and the shale loaded in trucks. At present the Government is winning about 700 tons per day, and it is used chiefly for fuel. The fines and smalls are sent to the cement works at Kunda, where in a crushed state the material is blown into the rotary kilns, giving a white-hot flame, while the ash is incorporated in the clinker bringing it to the requisite chemical composition.

Asbestos in Barberton District.—In an article in the *South African Journal of Industries* for March, A. L. Hall, Assistant Director of the Geological Survey, describes the geologically interesting and commercially attractive occurrences of asbestos on the farm Joubertsdal, in the Barberton district of the Transvaal, which are being worked by the Amianthus Mines, Ltd. Although chrysotile-asbestos was found as far back as 1905, during Mr. Hall's examination of certain parts of the De Kaap valley below the Drakensberg escarpment, near the Kaapsche Hoop, it is only as the result of renewed attention directed to the base-metal and mineral resources of the Union during the last few years that the serpentine belt of the Jamestown Series has been systematically prospected. The existence of deposits of chrysotile in commercial quantity and quality in that formation has now been definitely established, and their development has reached the producing stage. The workings in question lie in the south-western corner of the farm Joubertsdal and west of the main creek that traverses it from south to north, but the asbestos line continues eastwards across the creek into the adjoining Government ground. The total length over which fibre has been located at intervals is in the neighbourhood of three miles including both the Joubertsdal workings and those of Messrs. Myburgh and Munnik. On Joubertsdal the asbestos line has been more or less continuously proved over some 800 yards along the east and west strike, and, in conformity with the synclinal arrangement, a further development has been located and opened up at the northern end of the sheet of green serpentine.

The seams are nearly always restricted to the plane of contact between the two varieties of basic rock, and extend through a variable width up to 15 ft. from that contact downwards into the sheet of green serpentine. No fibre has so far been met with in the overlying blue serpentine. On Joubertsdal the horizon for the most part coincides with the lower contact between the two basic rocks, and this distribution is so marked and persistent, that it strongly indicates some genetic condition depending upon the constant association of two varieties of basic rocks. One arrives at such a conclusion from a study of the Joubertsdal workings alone, and it is much strengthened by the fact that further east along Myburgh's working the fibre line is similarly restricted to the junction between the green and the blue rock, but now it is along the upper contact of the same sheet.

It has been emphasized that the contact marking the upper limit of the fibre horizon is between two varieties of basic rocks, a rule which holds good right along the asbestos belt. One exception was, however, found in a portion of the New Strike, where the fibre horizon terminates upwards against a band of quartzite. Its whole thickness is not yet exposed, but probably amounts to not less than 10 ft. The rock appears to be in situ, as it gives rise to a short krantz-like feature, traceable for at least 50 ft. along the strike; it is a thickly bedded evenly fine-grained pale greyish rock, of which the thin section strongly indicates a sedimentary origin. It is made up of many grains of quartz—some with undulatory extinction—associated with a few flakes of white and more numerous flakes of altered black mica. Scattered through the section are rounded grains of chert and other fragments; there is very little or no groundmass. Though the quartz grains are not well rounded, their general characters recall those incidental to arenaceous rocks, and this is supported in one or two cases by the phenomenon of secondary enlargement of the original grain. Taken together, the appearance of the slide is in marked contrast to that of a typical Black Reef quartzite, while the habit of some of the mica is likewise not that of igneous rocks. It is also clear that at the New Strike a possible Black Reef quartzite at the top of the asbestos horizon would be several hundred feet out of position with no indication of being brought into such a position by faulting. For these reasons it is more probable that the local presence of this quartzite is an instance of the association within the Jamestown Series of subordinate occurrences of sediments.

From the New Strike the quartzite, marking the upper limit of fibre-bearing width of green serpentine, can be traced at intervals for about half a mile northwards, so that this secondary fibre-line is aligned more or less at right angles to the primary or main line. While the latter clearly follows the contact between the green and the blue serpentine along the entire length of the asbestos belt from Joubertsdal eastwards, the secondary fibre line appears to depend upon the contact between the green serpentine and an associated band of quartzite, is distributed across the main line, and restricted to the western portion of Joubertsdal.

On Joubertsdal the chrysotile line has been opened up by a large number of prospecting pits, irregular small quarries, and other open-cut workings, but including two major adits. These are aligned true north and south, each about 120 ft. long. At a point from 40 to 50 ft. vertically below the surface, each adit leads into drives along the fibre line, which has been followed for a combined distance of 360 ft. At the development referred to as the New Strike several adits have been put into the hill at the base of the fibre horizon and some 90 ft. long, whence the latter has been followed along the strike by means of a drive about 100 ft. long, and also further opened up by a series of irregular workings, more or less in the direction of dip, so that the chrysotile horizon is exposed over several hundred feet.

The various workings are along a nearly east and west strike, but in conformity with the anticlinal structure, the strike is tending south-westwards the further one goes west towards the extreme westerly or Bush Gully workings. Those developments which follow the southern edge of the syncline may be grouped as the Southern Workings, while those situated at the northern edge constitute the Northern Workings. The more important group and the principal sources of present supply is the southern one.

On the eastern extension of the asbestos line, on Lot No. 165, Messrs. Myburgh and Munnik's principal developments consist of a shallow straight open-cut working several hundred feet in length following the upper contact between the green and blue serpentine.

The asbestos is all of the chrysotile kind, and in the form of cross-fibre seams made up of very delicate white silky fibre of superior quality without foreign admixture. The most striking feature about these seams is their remarkably regular distribution and great number. They are in practically all outcrops almost strictly parallel to one another and to the plane of contact between the green and blue serpentine, in marked contrast to the occurrence of chrysotile in serpentine described from many localities in other parts of the world, where the seams form an irregular network. The dip varies from about 10° to 25°, and, in conformity with the structure, is directed towards the north in the southern and to the south in the northern workings. Through a vertical thickness of 7 ft. the serpentine is densely packed with a very large number of parallel seams, amounting to fifteen seams per linear foot over the uppermost part of the face, and increasing to thirty seams per linear foot a little lower down, individual seams ranging from ½ in. in width downwards. So regular is their distribution that the resulting alternation may be compared to the appearance of the "calico" or "bacon" rock familiar in certain varieties of banded ironstone. It is easy to collect examples where this "banded" chrysotile rock shows an alternation of asbestos seams and serpentine as regular as ruled paper. Incidentally, these data show that, subject to adjustments depending upon differences in specific gravity, the face, through a thickness of about 7 ft. consist roughly of 40% of chrysotile and 60% rock. In one of the exposures the zone of evenly spaced seams is 7 ft. thick, and is underlain by more green serpentine in which the seam "density" (that is, the number of seams per linear foot) decreases so that the fibre bands are farther apart, while individual seams become much wider, up to 3 in. and more.

Along the drive at the New Strike the banded fibre rock has a width of 7 ft. and shows many parallel seams, none of which are under ¼ in. thick, while ten seams are made up of fibre about ¾ in. long. At one point a seam 8⅝ in. in thickness was met with, but interrupted by a plane of discontinuity.

At the end of one of the adits belonging to the New Strike, and known as the "Ribbon Adit", the regularly banded character of the fibre is very strikingly displayed for over 90 ft. from the surface along the dip; the chrysotile-bearing zone maintains a thickness varying between 5 ft. and 7 ft., and the face of the adit now measures 7 ft. by 7 ft., the whole of which is ribbon rock; in this over 150 parallel seams of fibre were counted, ranging from + or − ¼ in. up to 1½ in., the great majority corresponding to the lower of the above limits.

The outstanding features in the Joubertsdal chrysotile belt—represented over and over again—are therefore: the large number of seams, their marked parallelism to one another and to the plane of contact between their country rock and the overlying blue serpentine or quartzite, their total absence in the latter, the progressive variation in seam density and width depending upon distance from the contact plane, and, finally, the maintenance of such conditions (as regards essential points) over a distance of at least 800 yards with a recurrence of similar phenomena, though on a smaller scale, in Myburgh and Munnik's workings some two miles further east, likewise intimately associated with the contact plane of two basic sheets. It is these features which render the natural history of chrysotile of special interest, as it is written in the Kaapsche Hoop area. While the writer found a single instance of a regularly and finely banded chrysotile rock in 1905 on Honing Krantz, south-west of Pretoria, no record could be traced in the literature of similar conditions in any other chrysotile occurrence.

Phosphates in Petroleum.—In *Economic Geology* for April, Chase Palmer gives the results of investigations into the presence of phosphates in California petroleums. The importance of this subject lies in the deduction that phosphate and nitrogenous matter found in oil point to an animal origin of petroleum. It is known that phosphates are found in the salt waters of the oilfields, and they are presumed to come from the oils in the district. Mr. Palmer reports that on a single section of the Sunset district, California, a heavy oil on close examination was found to contain phosphorus to the amount of one one-hundredth of one per cent of its weight. Another heavy oil drawn from a shallow well in the Kern River oilfield also showed a phosphorus content of one one-hundredth of one per cent. The phosphorus and nitrogen resemble each other closely in the properties of their compounds, and since nitrogen compounds constitute a large part of a Californian crude oil, consideration of the chemical nature of these nitrogen compounds throws light on the source of phosphates in oilfield brine solutions. Californian petroleums consist essentially of three very different classes of organic compounds, namely hydrocarbons, hydrocarbons with sulphur, and hydrocarbons with nitrogen. The nitrogenous hydrocarbons are usually called organic nitrogen bases. Members of all of these classes are oxidizable, but their oily nature shields them from direct attack of inorganic oxidants mobile in the waters or fixed in the rocks. The organic nitrogen bases, however, form soluble salts with strong acids, so that considerable quantities of these nitrogen bases are undoubtedly dissolved by the corrosive waters of the oil measures and the resulting solutions of organic nitrogen salts, necessarily in a state of high dilution, can offer little resistance to the attacks of oxidants. In 1899 Mabery prepared a long series of organic nitrogen bases by distilling an oil from Santa Paula, California. More recently Mabery and Wesson have shown that under certain conditions an inorganic oxidant, like potassium permanganate, oxidizes these organic nitrogen bases to organic nitrogen acids, while under other conditions ammonia is formed. Appreciable amounts of ammoniacal compounds and of organic nitrogen are therefore to be expected in a water closely associated with a Californian oil. The organic acids obtained by Mabery are derivatives of pyridine, an important constituent of bone oil produced by distilling the bones of vertebrates.

Waters from the oil measures of the Sunset, Midway, Kern River, and Coalinga fields were found to contain nitrogen compounds in the forms of free ammonium salts and of organic nitrogen acids, often in large amounts. These products conform to the products which Mabery and Wesson obtained by oxidizing the organic nitrogen bases extracted from the oil from Santa Paula. Nitrogen compounds were not looked for in every water in which phosphate was known to be present, but whenever nitrogen compounds were sought in phosphate waters they were found. A well that has been producing both oil and water in the Sunset district furnishes strong evidence that the oil has suffered powerful mineral oxidation. The water solution brought up with the oil and primarily a brine, itself somewhat modified by the mineral material which it has dissolved out of the rocks, was found also to contain free ammoniacal compounds as well as organic nitrogen compounds in amounts corresponding to 335 parts of ammonium chloride and 1,635 parts of organic nitrogen acids in one million parts of the solution. This water also contained 2·7 parts of phosphate per million. The presence of phosphorus in Californian oils and the usual association of phosphates with the soluble oxidation products of organic nitrogen bases in the waters of the oil measures point to the oil as the source of these phosphates.

When nitrogenous organic matter decays under atmospheric conditions nitrites and nitrates are among the final oxidation products, and surface waters polluted by decomposing organic matter often contain nitrogen in all the four forms that have been mentioned. It is a striking fact that these aqueous solutions brought up by the wells, solutions which have reacted with the oils underground, and are charged with ammoniacal salts and organic nitrogen acids, have failed to show the presence of nitrates and nitrites. The organic nitrogen bases of the petroleum, therefore, normally suffer only partial oxidation underground, the limit of oxidation coinciding with the limit which Mabery and Wesson reached by oxidizing the organic nitrogen bases of Santa Paula oil with potassium permanganate.

Manganese dioxide and other higher oxides of manganese are freely distributed in the oil regions of California. With corrosive brines they would form soluble manganous chloride and halogen, which by a cycle of well-known reactions easily produces active oxygen from the solution. Oil-field solutions usually contain manganous chloride, formed probably by the reduction of a manganic oxide by the organic nitrogen salts dissolved from the oil. Moreover, higher oxides of manganese seem to be easily accessible, because the muds brought up with the oil and water often contain the dark oxides of manganese.

To learn whether the dual occurrence of phosphorus in oils and waters is peculiar to the oil measures of San Joaquin Valley, examination was made by the author of an emulsion from the Ventura oilfield close to the Pacific coast and about 14 miles distant from Santa Paula. The permanent emulsion still contained 53% of suspended water and about 0·005% of mineral material that could not be removed. Manganese was found in this residue which had been held up in the emulsion. The oil in this emulsion was found to contain phosphorus to the amount of 0·008% of its weight. The water set free from the emulsion is a brine containing free ammonium salts and organic nitrogen compounds in abundance. A very small quantity of soluble manganous salt is also present. The water was perfectly free from nitrites and nitrates, but it contained as much as 5·2 parts of phosphate per million. The activities in the Ventura oil measures are evidently like the activities in the oil measures of San Joaquin Valley.

The author concludes by saying that the association of phosphorus compounds with nitrogen compounds in oils of different fields is another link in the chain of evidence that Californian petroleum is of animal origin.

Preserving Mine Timber.—The March *Journal* of the South African Institution of Engineers contains a paper by L. D. Hingle on the preservative treatment of mine timber by means of the waste zinc sulphate solutions arising from the refining of cyanide bullion. An incidental advantage of this method is that the solution renders the timber fireproof.

When the writer of the paper first investigated the problem of preserving mine timber, the feasibility of treating timber locally appeared to him to depend on the possibility of making use of the zinc sulphate residue from the treatment plants on the Rand. Creosote could not, and still cannot, be taken into consideration owing to its high cost, and quite apart from this important factor, the objection of inflammability would in many cases be a fatal one where mine timber is concerned. Zinc chloride had given satisfactory results in many countries, but there was no information available as to the toxicity of the sulphate to the wood-destroying fungi. It appeared possible that the sulphate had not been used before on a practical scale owing to the chloride being the salt more commonly available. It was therefore considered desirable to erect a small experimental plant for the purpose of investigating the toxicity of the waste zinc sulphate liquor to the wood-destroying fungi. Experiments were accordingly carried out on the mines of two companies belonging to the Central Mining-Rand Mines group, namely the Rose Deep and the Consolidated Main Reef. It was decided that the most convenient method of treatment to attempt in the first place would be the non-pressure or open-tank process. A pressure system would require an expensive plant which could operate economically only on a large scale, and after the value of the zinc sulphate as a preservative had been proved. The tests were commenced on the Rose Deep in the early part of 1919, and on the Consolidated Main Reef a few months later. In the nature of the case it was obvious that some considerable time had to elapse before definite results could be observed, but an opinion can now be formed as to the protection afforded the timber by the application of the zinc sulphate.

At Rose Deep the timber was treated in a vat 16 ft. long by 4 ft. wide and 4 ft. deep, a solution containing about 9% zinc sulphate being employed. Seasoned 4 in. lagging poles and 8 in. diameter props were chosen for the experiment, a proportion being set aside untreated to be sent underground as test pieces simultaneously with the treated. The preliminary hot bath was provided by the application of steam, after which the solution was allowed to cool, the total time of treatment being thirty-six hours. The timbers were then removed from the vat and allowed to dry, after which they were placed in certain places in the mine during June, 1919, side by side with the untreated test pieces. The places chosen for the timber were various points along the 2nd Level, No. 4 Shaft, where untreated timber was known to rot quickly, and on the Engine Plane, where similar conditions existed. The timber concerned in this experiment was examined during September, 1921, when it was found that on the 2nd Level the treated members were still hard and good and in a splendid state of preservation ; on the other hand, the untreated timber which had been subjected to the same atmospheric conditions for the same length of time crumbled away on being tested with a pick, and had obviously been of no practical use for some considerable period. Similarly, on the Engine Plane, all 8 in. props and 4 in. lagging which had been subjected to treatment were found to be in a good state of preservation, while untreated lagging which had been placed in the same vicinity as much as a year later than that treated was found to be in very poor condition.

At Consolidated Main Reef the solution employed was a mixture containing 2½% zinc sulphate and 2½% sodium chloride. A number of peeled and seasoned 8 ft. by 4 in. lagging poles of uniform quality were selected, one-half being taken to the shop-yard to be treated, the remainder being set aside untreated to be placed underground with the treated. The treatment was carried out in two old boiler shells, approximately 16 ft. long and 3 ft. in diameter, some of the top plates being cut out to facilitate the handling of the timber, while the boiler shell required for the hot treatment was equipped with a steam coil. The timber was given an initial treatment lasting 7 hours with the solution kept at boiling point, after which the poles were transferred to the cold solution and left there for twelve hours. The treated poles, after drying off, were sent underground and built into pigstyes on various levels, a lead tag being affixed to each pigstye showing the date on which it was built. Alongside each of these pigstyes formed of treated timber was built a pigsty of the untreated timber, and a record was kept of the various places in which they were installed on the different levels. The first of these sets of pigstyes was built in January, 1920, and the last in August, 1920. Until the middle of 1921 there was no appreciable difference between the treated and untreated timber, but a few months later the difference had become most marked. The untreated timber was obviously rotting rapidly, while in every case the treated was in a much better condition. When inspected during September, 1921, the appearance of the pigstyes built of untreated timber indicated that within a few months they would have rotted completely and fallen out, if not previously removed. In the light of the Rose Deep results the addition of sodium chloride is obviously unnecessary and should not be adopted.

It is advisable to emphasize the necessity of peeling and thoroughly seasoning all timber before the preservative is applied. In any event, apart from the question of treating with preservatives, the practice of allowing unseasoned or unbarked timber to be sent into a mine is a very bad one, and should never be countenanced.

Nickel-Copper Deposit in Canada. — In the *Canadian Mining Journal* for May 5, J. G. Cross describes a deposit of nickel and copper recently discovered on Shebandowan Lake, about 70 miles west of Port Arthur, Lake Superior. The chief ore mineral is pyrite, with subordinate amounts of pyrrhotite. Nickel, in the form of polydymite, and copper as chalcopyrite, are present abundantly. Cobalt is present in much lesser amounts, averaging about 0·3% of the ore. Nickel and copper occur in about equal amounts, although there are zones extraordinarily rich in each of these metals, with little admixture. The rare arsenides, skutturudite and gersdorffite, have been identified. Niccolite, and possibly other minerals occur also.

Keewatin rocks are exposed everywhere along the shore of the lake, except on part of the south side of the middle lake, and on the north side of the lower lake, where granite, probably of Algoman age, occurs. The Keewatin in the vicinity of the nickel-copper deposit is a dark-green basic schist, dipping at a steep angle, the strike following approximately the contact with the granite. Dykes of serpentine, granite, and porphyry also follow the contact. The ore occurs in the vicinity of these dykes. There is a large area of serpentine about a mile to the south. It is possible that the ore is in some way connected with this serpentine, as is the case at the Alexo mine and elsewhere at Sudbury.

The ore occurs as a series of lenses, more or less parallel, and connected by vein-like occurrences of ore. The lenses vary from 2 to 20 ft. or more in width, and the length is proportional to the width. The ore in places is massive. The massive ore is rich, and carries from 8 to 12% nickel. Massive chalcopyrite is of less common occurrence. Three feet of the ore carries 15% copper in a pit near the lake shore. The nickel-bearing mineral is polydymite, no pentlandite having as yet been identified. In this respect the ore differs from well-known occurrences elsewhere. The platinum content of the ore is noteworthy. This is not surprising, as the ore is associated with much serpentine, and ultrabasic rocks. Gold and silver occur only sparingly, averaging about $1·00 to the ton. A sample submitted to the Geological Survey for examination was reported to contain platinum metals at the rate of 0·16 oz. per ton.

SHORT NOTICES

Mining Practice.—At the meeting of the Institution of Mining and Metallurgy, held on May 18, a paper on "Clean Reef-Mining and its Influence on Mining Costs," by L. G. Hutchison, was read and discussed.

Roller and Ball Bearings. — The *Colliery Guardian* for May 5 contains an illustrated article on the application of roller and ball-bearings to mining plant of all kinds, car-wheels, rope-way pulleys, pumps, winding engines, etc.

Tin Dredging.—In the *Engineering and Mining Journal-Press* for May 13, P. R. Parker gives an account of the erection and work of the Bucyrus dredge at the Tin Bentong mine, Pahang. Particulars of this dredge were given in the MAGAZINE for April, 1918.

Iron Ore Concentration.—In the *Engineering and Mining Journal-Press* for May 6, H. H. Wade describes a magnetic log washer for use in iron ore concentration.

Mount Bischoff Concentration.—At the meeting of the Institution of Mining and Metallurgy held on May 18, C. W. Gudgeon presented a paper on the method of concentrating pyritic tin ores, introduced at Mount Bischoff, Tasmania.

Blast-Furnaces.—At the meeting of the Iron and Steel Institute held on May 4, D. E. Roberts read a paper on the apparatus used in blast-furnaces for feeding and distributing the charge.

Copper Metallurgy.—In the *Engineering and Mining Journal-Press* for April 26 and May 6, Joseph Irving writes on the heap leaching of low-grade copper ores, with an account of experience at Bisbee, Arizona.

Estimation of Lead.—The *Journal of Industrial and Engineering Chemistry* for May contains a paper by D. A. MacInnes and E. B. Townsend describing an electro-volumetric method for lead. Lead peroxide, deposited electrolytically, is determined by solution in oxalic acid, and titration of the excess acid with potassium permanganate.

Cyanide Practice. — In the *Engineering and Mining Journal-Press* for May 20, E. R. Richards describes the method employed at Buckthorn, Nevada, for smelting cyanide gold-silver precipitate, and investigations as regards fume losses.

Titanium Pigments. — At a meeting of the Royal Society of Arts held on May 3, Noel Heaton read a paper on white pigments, consisting of titanium oxide, now prepared by a Norwegian company on a large scale.

Sodium.—*Chemical and Metallurgical Engineering* for May 10 and 17 contains an article by H. E. Batsford on the history and development of the production of metallic sodium.

Mica.—In the *Engineering and Mining Journal-Press* for May 20, J. Volney Lewis writes on the geology and mining of mica.

Portuguese East Africa. — The *Geological Magazine* for May contains a paper by R. R. Walls on the geology of the northern section of Portuguese East Africa, between Lake Nyasa and the Indian Ocean.

Cobalt, Ontario. — In the *Engineering and Mining Journal-Press* for May 6, Cyril W. Knight, of the Ontario Geological Survey, writes on "Cobalt, its Past and Future."

RECENT PATENTS PUBLISHED

☞ *A copy of the specification of any of the patents mentioned in this column can be obtained by sending 1s. to the Patent Office, Southampton Buildings, Chancery Lane, London, W.C. 2, with a note of the number and year of the patent.*

27,493 of 1920 (151,644). A. E. Bourcoud, New York. Improvements in the reduction of iron and other oxides by reaction with reducing gases.

28,359 of 1920 (152,029). Metals Extraction Corporation of America and A. Schwarz, Joplin, Missouri. Improvements in the process for the recovery of certain volatilizable metals such as zinc from complex ores, after roasting, by reaction with a reducing agent in such a way that the roasted ore will not be removed by the usual draught.

33,818 of 1920 (155,246). Moa Iron and Development Co., C. R. Hayward, H. M. Schleicher, and F. O. Stillman, New York. Improvements in the inventors' method of treating Cuban iron ores which contain nickel, aluminium, chromium, etc., with the object of recovering the other metals.

34,141 of 1920 (177,839). T. R. Simpson and Minerals Separation, Ltd., London. Recovery of elemental sulphur from mineral matter by the flotation method.

35,008 of 1920 (155,824). Fabriques de Produits Chemiques de Thann et de Mulhouse, France. Method of producing a zinc sulphide suitable as a pigment by reaction on a zinc salt by a barium polysulphide.

300 of 1921 (177,615). F. Ondra, Johannesburg. A concentrating machine in which the crushed ore is projected with a fluid as a jet and the particles of equal weight thus classified, and subsequently these products classified according to size.

446 of 1921 (159,865). O. Rebuffat, Naples. In the manufacture of silica bricks, preliminarily exposing the crushed quartz to a sufficiently high temperature to convert it into tridymite.

485 of 1921 (156,552). W. Mathesius, Charlottenburg. In the manufacture of lead-calcium bearing metals, the addition of small portions of barium and strontium in order to lower the melting point of the alloy.

730 of 1921 (156,696). H. Löwy, Vienna. Means for electrically prospecting for minerals or water from the air, comprising in combination a flying machine with an antenna, which is maintained at constant position with respect to both the vehicle and the ground, and forming an open oscillator capable of being used for measuring purposes.

1,385 of 1921 (157,455). W. Weber & Co., Wiesbaden, Germany. Conduits for flushing tailing and mine waste to considerable distances.

1,390 of 1921 (157,459). W. Weber & Co., Wiesbaden, Germany. Removing gravel from the face by means of a jet carried on a travelling car, which also carries a hopper close to the face to receive the moved gravel, the gravel being carried hydraulically by pipes from the hopper to the place required.

1,500 of 1921 (157,785). E. Slatineanu, Geneva. Electrolytic method of separating gold and palladium from platinum.

1,918 of 1921 (178,203). T. A. Brown and C. Walker, Sheffield. In shaft-sinking and similar operations carried out by the cementation method, in which the drilling of the holes for the introduction of the cement is effected by the aid of hollow or tubular plug devices inserted in holes in the floor of the excavation and fitted with valve fittings which may be opened to permit of the working drills to pass through, the employment of a foundation ring or erecting ring as an abutment means for preventing the plug devices from being ejected from their holes.

2,119 of 1921 (165,767). New Jersey Zinc Co., and W. L. Coursen, New York. Improved method of making zinc oxide by the retort volatilizating process.

3,260 of 1921 (158,827). A. Pacz, Cleveland Heights, Ohio. An aluminium-silicon alloy of high tensile strength and low coefficient of heat expansion.

3,328 of 1921 (178,587). H. H. Thompson and A. E. Davies, Birmingham. An improved magnetic separator of the rotary drum or ring type, in which one or more arcuate or segmental stationary armature pieces are arranged to partially surround the drum or ring, the inner faces of the armature pieces being concentric with the periphery of the drum or ring, but spaced a short distance therefrom.

3,469 of 1921 (159,500). Fried. Krupp, Essen, Germany. Iron lining for shafts of box-girder cross section, intended for giving resistance to bending action as well as resistance to outside pressure.

3,793 of 1921 (174,026). WERF CONRAD, Haarlem, Holland. Improved construction of drilling jar for use in boring operations.

4,189 of 1921 (161,560). W. E. TRENT, Washington. Separating fine mineral from gangue, by adding oil and pulverized coal and producing a mixed flotation concentrate consisting of the fine mineral and the oil and coal.

NEW BOOKS, PAMPHLETS, Etc.

☞Copies of the books, etc., mentioned below can be obtained through the Technical Bookshop of *The Mining Magazine*, 724, Salisbury House, London Wall, E.C. 2.

Electro-Deposition of Iron. By W. E. HUGHES. Bulletin No. 6 of the Department of Scientific and Industrial Research. Price 6s. 6d. London: H.M. Stationery Office.

Canadian Mining Handbook. By W. A. MORGAN. Pamphlet, 54 pages. Price 1s. 6d. London: Walter R. Skinner. This publication gives an outline of the mineral resources of Canada, and particulars of public mining companies operating there; it should be of use to those who appreciate the mining possibilities of the Dominion.

Geological Map of Boston-Skead Gold Area, Ontario. Published by the Ontario Department of Mines. This district includes Boston Creek, and is situated to the south-east of Kirkland Lake.

Geology of the Western Railway of Nigeria. By R. C. WILSON and A. D. N. BAIN. Paper boards, quarto, 64 pages, with many plates and other illustrations. Price 17s. 6d. Published by the Nigerian Government; London Agency: Crown Agents for the Colonies, 4, Millbank, Westminster. This is Bulletin No. 2 of the Geological Survey of Nigeria, and covers the geology of the land through which the railway runs from the coast at Lagos to near Ilorin.

Gowganda and other Silver Areas, Ontario. By A. G. BURROWS. Pamphlet, 54 pages, illustrated. Toronto: Ontario Department of Mines.

Ontario Gold Deposits. By PERCY E. HOPKINS. Pamphlet, 75 pages, illustrated. Toronto: Ontario Department of Mines. This pamphlet contains a review of the geology, distribution, and production of the gold deposits of Ontario, and contains a concise and reliable description whereby the performance and opportunities may be readily judged.

Barytes and Witherite. By G. V. WILSON, and others. Octavo, paper covers, 120 pages, illustrated. Price 3s. London: H.M. Stationery Office. This is the third edition of one of the special reports on the mineral resources of Great Britain prepared by the Geological Survey.

Lead and Zinc in Cardigan and Montgomery. By O. T. JONES. Octavo, paper covers, 210 pages, illustrated. Price 7s. London: H.M. Stationery Office. This is Vol. XX of the special reports on the mineral resources of Great Britain prepared by the Geological Survey. The report gives an account of the lead-zinc district of central Wales, which includes the Cwmystwyth, Frongoch, and Van mines.

Short Guide to the Museum of Practical Geology, Jermyn Street. Third Edition. Pamphlet, 44 pages. Price 2d. For sale only at the Museum.

Notes on Asbestos; Notes on Zinc and Lead: Notes on Barytes and Mineral Colours. By DR. J. COGGIN BROWN, Superintendent, Geological Survey of India. Bulletins 19, 20, and 22 of Indian Industries and Labour, published by the Government of India.

Annual Report of the Minister of Mines of British Columbia, 1921. Paper covers, large octavo, 364 pages, with many maps and illustrations. This report is prepared by the Provincial Geologist, W. Fleet Robertson, and gives details of the progress of mining ventures during 1921.

Graphic and Mechanical Computation of Thickness of Strata and Distance to a Stratum. By J. B. MERTIE. Professional Paper 129c of the United States Geological Survey.

Mineral Resources of Burma. By N. M. PENZER. Cloth, octavo, 178 pages, with maps. Price 31s. 6d. London: George Routledge & Sons, Ltd.

Report of the Fuel Research Board for 1920–21, Second Section, Low-Temperature Carbonization. Price 2s. London: H.M. Stationery Office.

The Petroleum Industry. Edited by A. E. DUNSTAN. Cloth, octavo, Price 14s. 6d. London: Institution of Petroleum Technologists. This book consists of a review based upon lectures given at the Petroleum Exhibition at the Crystal Palace in 1920. The contributors are Sir Frederick Black, E. H. Cunningham Craig, G. Howell, H. May, H. Barringer, F. B. Thole, W. R. Ormandy, J. S. S. Brame, J. Kewley, A. W. Eastlake.

COMPANY REPORTS

Springs Mines.—This company belongs to the Consolidated Mines Selection group, and was formed in 1909 to work a gold property in the Far East Rand. Milling commenced in 1917. Additional ground to the south was acquired under lease from the Government in 1917. The report for 1921 shows that 569,241 tons was raised, and after sorting, 484,590 tons averaging 9·37 dwt. per ton was sent to the stamps. The yield of gold by amalgamation was 95,043 oz., and by cyanide 118,655 oz., making a total of 213,698 oz. The par value of the gold was £901,828, and £215,746 was received as premium, making a total revenue of £1,117,574. The working cost was £719,771, leaving a working profit of £397,803. The yield per ton at par was 37s. 2d., the premium 8s. 11d., the working cost 29s. 8d., and the profit 16s. 5d. The shareholders received £197,585, the rate being 15%. Government taxes and participation absorbed £54,571, and £127,239 represented extra expenditure on development over the fixed 5s. per ton. The developments in the eastern section have continued to disclose excellent ore, and the reserve is now estimated at 3,056,231 tons averaging 8·92 dwt. per ton, as compared with 2,726,178 tons, averaging 8·76 dwt. the year before. No. 3 shaft on the leased ground has been completed, and it should be put in commission shortly. It is expected that the new plant, by means of which the capacity will be raised to 52,000 tons per month, will be ready in a few months.

Brakpan Mines.—This company belongs to the Consolidated Mines Selection group, and was formed in 1903 to work a gold property in the Far East Rand. Milling commenced in 1911. Additional property was acquired on lease from the Government in 1916. The report for 1921 shows that 771,622 tons was raised, and after sorting 659,350 tons averaging 8·94 dwt. per ton was sent to the stamps. The yield of gold by amalgamation was 197,983 oz., and by cyanide 87,244 oz., making a total of 285,227 oz. The par value of this gold was £1,122,126, and the premium received was £265,339, making the total revenue £1,387,465. The working cost was £897,218, leaving a working profit of £490,246. The par value of the yield per ton was 34s., the premium 8s., the cost 27s. 2d., and the profit 14s. 10d. The shareholders received £255,000, the rate being 30%. Taxes and Government participation in profits absorbed £101,294, and £180,000 was placed to capital expenditure on the leased area. The results of development during the year were generally favourable, and the reserve stands at 2,423,230 tons, averaging 8·61 dwt. per ton, as compared with 2,526,517 tons averaging 8·88 dwt. the year before.

New Goch.—This company was formed as the George Goch in 1887 to work property on the outcrop in the central Rand. The control is with the Albu group. The profits have never been great, and during the last few years the position and prospects have been very uncertain. The report for 1921 shows that 209,394 tons of ore was mined, and after sorting, 196,200 tons, averaging 5·24 dwt., was sent to the mill. The yield of gold by amalgamation was 29,538 oz., and by cyanide 15,525 oz., making a total of 45,063 oz. The value of this gold, including premium, was £237,571, and the working cost was £227,217, leaving a profit of £14,366. The reserve is calculated at 47,479 tons, averaging 6·7 dwt., taking gold at par. If gold is 95s. per oz., an additional 15,958 tons, averaging 5·6 dwt., may be included in the reserve. There is also much ore left in pillars and in the Main Reef, the value of which cannot be readily calculated. The fall in the cost of labour and stores may also add to the life of the mine.

Meyer and Charlton.—This company belongs to the Albu group, and was formed in 1888 to acquire a property on the outcrop in the central Rand. Additional property on the dip was acquired in 1909. The mine, though small, has been remarkable for the continued richness of the Main Reef Leader. The report for 1921 shows that 163,330 tons, averaging 12·05 dwt. gold per ton, was raised and sent to the mill. The yield of gold by amalgamation was 34,326 oz., by cyanide 42,239 oz., and from concentrates 20,494 oz., making a total of 97,059 oz., worth, with premium, £512,440. The working cost was £219,040, leaving a working profit of £293,400. Dividends absorbed £200,000, being at the rate of 100%. The ore reserve is estimated at 358,522 tons, averaging 14·52 dwt. in the Main Reef Leader, 33,565 tons, averaging 6·56 dwt. in the Main Reef, and 3,800 tons, averaging 6·7 dwt. in the South Reef, the total being 395,887 tons, averaging 13·77 dwt. A year ago the total reserve was 450,050 tons, averaging 14·1 dwt., and at the end of 1919 the figures were 516,489 tons, averaging 15·5 dwt. This estimate does not include pillars and hanging-wall and foot-wall reefs; the quantity of ore derived from these sources during 1921 was 78,398 tons.

Aurora West United. — This company was formed in 1891 to work a gold-mining property in the middle west Rand, and in 1897 the adjoining Aurora was absorbed. The control is with the Albu group. The profits have never been great, and during the last few years the position has been precarious. The report for 1921 shows that 136,785 tons was raised, and after the removal of waste, 122,410 tons, averaging 5·96 dwt., was sent to the stamps. The yield of gold by amalgamation was 23,807 oz., and by cyaniding 9,367 oz., making a total of 33,174 oz. The value of the gold, including premium, was £173,973, and the working costs were £167,414, leaving a profit of £6,559. The ore reserve is estimated at 136,700 tons, averaging 6·9 dwt. per ton, as compared with 32,050 tons, averaging 7·3 dwt. the year before. The increase in the reserve is due to satisfactory results of development obtained in the 15th level east on on the Main Reef Leader.

Roodepoort United Main Reef. — This company belongs to the Albu group, and was formed in 1887 to acquire gold properties in the western part of the Rand. Other adjoining properties were absorbed in 1898 and 1909. The report for 1921 shows that 260,230 tons of ore was raised, and sent to the stamps. The yield of gold by amalgamation was 38,958 oz., and by cyanide 13,169 oz., making a total of 52,127 oz. The revenue, including premium, from the sale of gold was £272,300, or 20s. 11d. per ton. The working cost was £285,769, or 22s. per ton, so that the year ended with a loss. As mentioned last month, operations are now confined to sweeping and washing the levels around Kimberley main shaft, and the final stoppage will not be long postponed.

Rezende Mines.—This company was originally formed in 1892, as the United Goldfields of Manica, to work property in the Umtali district of Rhodesia. It was reconstructed in 1898, 1905, and 1908. In 1912 the Penhalonga property was absorbed. Control is now with Sir Abe Bailey. The results have been very much better during the last two or three years than formerly, owing to continuous stretches of good quality ore having been developed in the east section of the property. The report for 1921 shows that 65,200 tons of ore averaging 10·8 dwt. per ton was raised and treated, and that 32,590 oz. of gold was extracted by amalgamation, cyaniding, and from concentrate. The revenue, including premium, was £160,955, or 49s. 4d. per ton, and the working cost was £93,841, or 28s. 9d. per ton, leaving a working profit of £67,113, or 20s. 9d. per ton. The dividends absorbed £48,000, the rate being 40%. The ore reserves have been well maintained, and stand at 140,512 tons averaging 9·5 dwt. per ton, as compared with 140,268 tons averaging 10 dwt. the year before.

Lonely Reef Gold.—This company belongs to the Lewis and Marks group and was formed in 1910 to work a gold mine 40 miles north of Bulawayo, Rhodesia. C. B. Kingston is the consulting engineer. The report for 1921 shows that 58,970 tons of ore averaging 21 dwt. per ton was sent to the mill, and that gold worth £239,223 at par was extracted. The premium brought a further £58,572, bringing the revenue to £297,795. The working profit was £133,720, out of which £32,866 was paid as taxes and £25,996 was written off for depreciation. The shareholders received £69,106, the rate being 30%. The development of the two lowest levels did not disclose ore of as high a grade as on those above, and the reserve now stands at 204,249 tons averaging 18·1 dwt. per ton, as compared with 202,845 tons averaging 20·8 dwt. a year ago. Owing to the decreased dip of the ore-body, a shaft is now being sunk to follow the ore from the 23rd level. The new gas-electric plant using wood in the producer is proving a great success.

Rhodesia Gold Mining and Investment. — This company belongs to the Lewis and Marks group, and was formed in 1910 to develop and finance gold-mining enterprises in Rhodesia. It controls the Lonely Reef, but has recently disposed of its interests in the Cam and Motor company. It works the Huntsman mine, and lets one or two other properties on tribute. The report for 1921 shows that the Huntsman mine was worked for the first three months of the year at full time and subsequently for about 11 days per month. The total ore treated was 4,208 tons, and the yield of gold 3,366 oz.; the profit after charging royalty and depreciation was £1,354. Development was done at the intermediate level between No. 4 and No. 5 levels, and on the 5th and 6th levels. The results were not very promising, but since the turn of the year ore of high grade has been found in the north drive of the 6th level. No work was done at the Sabi mine during the year. At the Bernheim mines there was a change in the tributing party, and owing to an accident at the power plant operations were suspended from March to October. During the time the plant was running gold worth £1,843 at par was extracted, and £1,229 was received as premium on the output from August, 1920, onward. The company's share of the receipts was £1,134. The company's accounts show profits on shares sold of £5,099, interest and dividends £8,315, and revenue from properties, etc., £6,744. The balance of profit was £11,902, out of which a dividend of 7½% tax paid has been distributed, absorbing £11,250.

Namaqua Copper.—This company has worked copper mines in Little Namaqualand, Cape Province, since 1887. Operations were greatly inconvenienced by the war, and smelting was suspended early in 1918. Since then it has been decided to add a converter plant. The report for 1921 shows that this converter plant is near completion, and that smelting will be resumed shortly. The production of copper precipitate from the leaching heaps during the year was 124 tons, containing 89 tons of fine copper. Development has been continued at the Homeep mine, and additional ore has been developed. Work has also been done at the Homeep East, or Success, mine. The reserves are as follow: Tweefontein, 33,381 tons, averaging 6% copper; Homeep, 30,000 tons, averaging 8%; Flat, 18,000 tons, averaging 6%; Homeep East, 20,000 tons, averaging 5%; and there is 68,000 tons, averaging 2·58%, in the precipitation heaps. The sales of precipitate during the year realized £7,957, and the deficit for the year was £13,247. Since this report was issued William Rich, the chairman and managing director, has suddenly died.

Esperanza Copper and Sulphur. — This company was formed in 1906 to acquire from local owners the Esperanza group of pyrites mines in the south of Spain. G. Murc Ritchie is chairman and T. D. Lawther is managing director. The report for 1921 shows that 59,431 tons of pyrites was raised, 69,524 tons was dispatched from the mine to the port of Huelva, and 63,066 tons shipped. The amounts were rather less than during the previous year owing to the industrial stagnation following the coal strike. The amount of copper precipitate produced was 67 tons. The proved reserve of ore is estimated at 811,000 tons. The profit for the year was £555, which was carried forward.

Golden Horse-Shoe Estates. — This company has worked a gold mine at Kalgoorlie, West Australia, since 1899. Handsome profits were made until 1909, but with the decline in the gold contents the profits have been much smaller since. Of recent years the high costs of labour and supplies have also proved serious drawbacks, but there now appears to be a prospect of an abatement in costs. The report for 1921 shows that 104,226 long tons of ore was raised and sent to the stamps. The yield of gold by amalgamation and cyaniding and from concentrates was 55,304 oz., worth £237,970 at par. In addition £60,306 accrued to the company from the premium realized. The profit was £44,841, of which £37,500 was distributed as dividend, being at the rate of 2½%. The ore reserve is estimated at 593,981 tons averaging 8·62 dwt. per ton, as compared with 637,330 tons averaging 8·74 dwt. the year before.

Ivanhoe Gold Corporation. — This company has worked one of the big gold mines of Kalgoorlie, West Australia, since 1897, and for many years paid handsome dividends. Since the downward limit of the ore was reached, at 2,420 ft., the output and profits have been smaller, and during the last year or two the increased costs, largely due to high wages and the scarcity of efficient labour, the profits have been still smaller. The report for 1921 shows that 153,583 tons of ore was sent to the stamps. Gold worth £75,020 at par was extracted by amalgamation, £53,456 by cyaniding concentrate, and £129,841 by cyaniding sand and slime. The total gold was £257,317; with premium the value was £320,219. The net profit was £41,988, and £45,000 was distributed as dividend, the rate being 4s. 6d. on the £5 share. The ore reserve is estimated at 799,573 tons averaging 32s. 6d. per ton, as compared with 861,786 tons averaging 34s. 4d. the year before.

Balaghat Gold Mines.—This company belongs to the John Taylor & Sons group of gold mines in the Kolar district, Mysore State, South India. It was formed in 1886, and was reconstructed in 1890, 1894, 1896, and 1919. The output has never been on anything like the scale for which the adjoining mines have been famous. Fair dividends were paid from 1900 to 1907. In 1919 developments at 4,000 ft. became encouraging once more, and further funds were then subscribed. Dividends have been paid for 1920 and 1921. The report for 1921 shows that 38,750 tons of ore was sent to the stamps, and that 23,102 oz. of gold was extracted by amalgamation. In addition 62,250 tons of current and accumulated tailing was cyanided for a yield of 5,740 oz. The gold was sold for £151,812, including premium. After payment of royalty, the net revenue was £144,751. The working cost was £108,225. The dividends absorbed £24,017, being at the rate of 2s. 3d. on the preference shares and 1s. 3d. on the ordinary shares, both of 10s. each. Development has continued to give good results, but owing to a water-bearing cross-course being encountered, there was an interruption in the work. Consequently the reserve was not maintained, the figure being 80,294 tons, as compared with 91,755 tons the year before. Work was confined to the Balaghat lode, but during the current year exploration of the main lode is to be undertaken and also an attempt is to be made to find it in depth. The new plant to deal with dumps on Nine Reefs and Road Block is nearly ready to start.

Plymouth Consolidated Gold Mines. — This company was formed in 1914 by Bewick, Moreing & Co., to acquire, on the recommendation of W. J. Loring, a gold mine in Amador County, California.

During the last few years scarcity of suitable labour and substantial increases in cost have combined to decrease the margin of profits and to hinder development work. Also the ore mined lately has been poorer. The report for 1921 shows that 102,000 tons or ore was raised and treated, for a yield of 25,940 oz. of gold, realizing £111,721, or 21s. 11d. per ton. The working cost was £118,964, or 23s. 4d. per ton, so that there was a loss. Allowance for depreciation and taxes brought the deficit to £16,203. The yield per ton was 4s. 9d. less than during the previous year, owing to the lower grade of ore developed on the 3,235 ft. and 3,400 ft. levels. On the other hand, the working cost was 10d. per ton less than in 1920, but it is still far higher than in 1915, when it was only 12s. 6d. per ton. There is some sign that during 1922 the cost of labour and supplies will show a decrease. There are indications that ore of higher assay-value will be found in depth, so sinking is being continued and the necessary plant has been ordered.

Keffi Consolidated Tin.— This company was formed in November, 1920, as an amalgamation of the Keffi Tin, Jemaa Exploration, Toro Tin, and Associated Nigerian Tin companies, operating on the Bauchi Plateau, Northern Nigeria. Allan A. Davidson is the manager. The report for the period to December 31, 1921, shows that the expansion of operations contemplated at the consolidation have been postponed owing to the low price of tin and the high cost of the new plant required, and just sufficient tin is being won to keep the camps together. The present output of tin concentrate is from 20 to 25 tons per month, and much of it is being held for shipment. The accounts show credits of £9,870 for concentrate, and expenses of £10,912. A fair amount of prospecting has been done. No exact estimates of the value of the ground can be given, but Mr. Davidson considers that 5,000 tons of cassiterite may be extracted profitably even at the present low price of tin and that there is another 5,000 tons partly proved ; also a large area of low-grade ground unpayable under present conditions. The latest discovery is a stretch of ground in the Bukuru area, 1,300 ft. by 550 ft., averaging 37 ft., and estimated to contain 3·1 lb. of cassiterite per cubic yard.

Mongu (Nigeria) Tin Mines.— This company was formed in 1914 by the Anglo-Continental Mines Co. to acquire alluvial tin ground in the Ropp district of the Bauchi Plateau, Northern Nigeria. A bucket-dredge was purchased in 1916. The report for 1921 shows that 567 tons of tin concentrate was won, of which 178 tons came from the dredge and 389 tons was obtained by sluicing and calabashing. During 1920 the output was 490 tons. The revenue for the year was £49,617, and the balance of profit was £2,468. The company's policy at present is to keep down the expenses in every possible way until trade recovers and the price of tin improves.

Premier Hydraulic Tin Mines of Nigeria.— This company was formed in 1920 by the Central Mining and Investment Corporation and others to work alluvial tin properties at Jemaa in the Nassarawa Province of Northern Nigeria. J. Jervis Garrard is the manager. The original design of plant to be employed was modified owing to the difficulties of transport, and more portable plant is now in course of erection and trial in this country before shipment. The report for the period from the date of formation of the company until June 30, 1921, shows that 114 tons of tin concentrate was won chiefly by tributers. The expenses during this time were £25,955, and the receipts from the sale of the product were £8,756.

Kampong Kamunting Tin Dredging. — This company was formed in the Federated Malay States in 1913 by Sydney capitalists to work alluvial tin ground at Taiping, Perak. A. W. Freeman is chairman and managing director, and C. Nardin is manager. The first dredge started in March, 1915, and the second in February, 1916. The report for the six months ended December 31 last shows that the two dredges handled 947,000 cu. yd. of ground for an extraction of 404 tons of cassiterite, being a yield of 0·96 lb. per yard. The income from the sale of concentrate was £36,489, and the net profit was £9,948. The dividends absorbed £10,500, the rate being 7½% for the half year.

Asam Kumbang Tin Dredging.—This company was formed in 1920 in the Federated Malay States as a subsidiary of the Kampong Kamunting mentioned in the preceding paragraph to acquire tin-dredging ground at Taiping, Perak. Dredging commenced in October, 1919. The report for the half-year ended December 31 last shows that 660,000 cu. yd. of ground was handled for an extraction of 205 tons of cassiterite, or 0·7 lb. per yard. The income was £18,686, and the net profit £181. Owing to the depressed condition of the tin market, arrangements for providing funds for the building of a second dredge are held in abeyance at present.

New Brunswick Gas and Oilfields. — This company was formed in Edinburgh in 1915 to acquire the property of the New Brunswick Petroleum Co., a Canadian company, and of the Maritime Oilfields Co. Dr. J. A. L. Henderson is vice-chairman of the company. The report for 1921 shows that the revenue from the sale of gas was £27,152, and from the sale of oil £5,947, while the net profit was £10,298. A 6% dividend on the ordinary shares absorbed £5,040, and a 4% dividend on the ordinary shares £2,240. During the year a new oil well (No. 56) was successfully drilled in the Stony Creek field to a depth of 2,849 ft., and is yielding oil. Another new well (No. 58) has reached the oil horizon, and is yielding oil in payable quantity. Six of the existing gas wells have been deepened, and are bringing in additional gas to the extent of over five million cubic feet per day, but at a reduced pressure. The gas is delivered to the city of Moncton for lighting, heating, and power purposes. The Anglo-Persian Co., whose contract through the D'Arcy Exploration Co. was mentioned last year, has operated three drilling crews throughout 1921.

Lobitos Oilfields.—This company was formed in 1908 to acquire oil lands in the northern coastal province of Peru. Other lands in Ecuador were subsequently acquired, and transferred to a subsidiary, the Anglo-Ecuadorian Oilfields, Ltd. Dividends have been paid since 1912. The company owns lands also in Colombia, which are awaiting development. The report for 1921 shows that the output of oil was 103,755 tons, as compared with 97,296 tons in 1920. The net profit for the year was £516,423, out of which £100,000 has been placed to reserve, £125,000 to taxation account, and £100,000 to the reduction of the cost of steamers account. The shareholders received £140,000, the [illegible] being 35 [illegible].